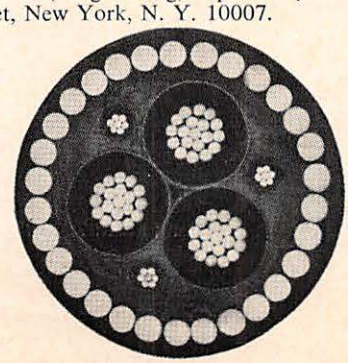
SEPTEMBER 1967

Railway Signaling & Communications

on guard

This is a nest of grouse eggs. A nest is a fragile concatenation of twigs, built by a delicate creature with no hands, but it is built to do a job, and it does that job to perfection. Within one classic circle, a nest is a home, a bed, and a protective shelter.

Below is a "plan" of a Kerite cable. Cables may look alike in cross-section, but a Kerite cable is as different from other cables as a nest is from random twigs. Kerite is built to do its job to perfection. Only the right combination of proved materials, engineering, experience, and technique makes it possible. The Kerite Company, 30 Church Street, New York, N. Y. 10007.

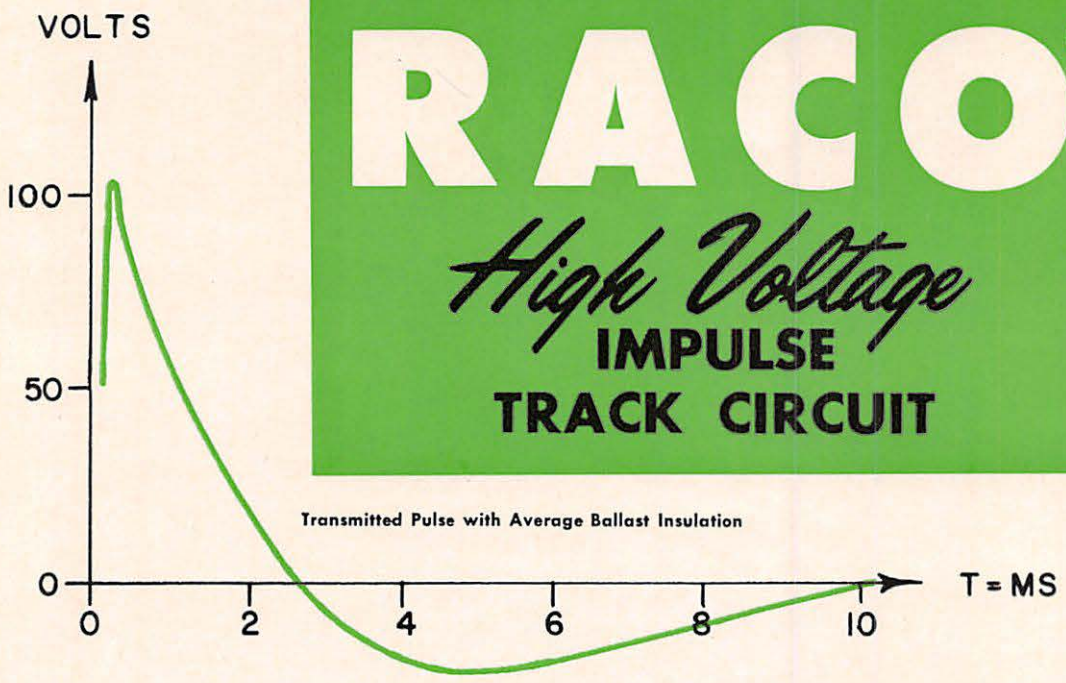


Kerite
the cable that lasts...and lasts...and lasts...

Simmons-Boardman **TIME-SAVER** Publication

RACO®

High Voltage IMPULSE TRACK CIRCUIT



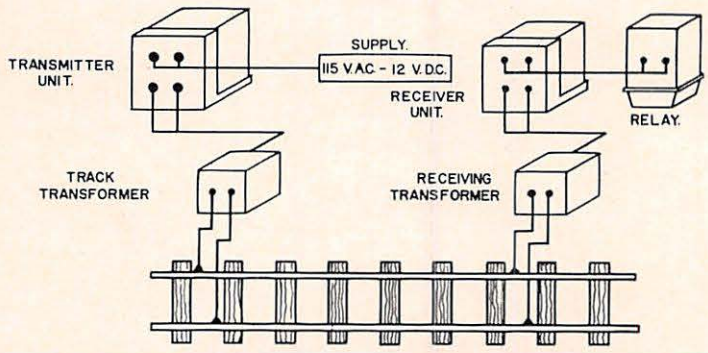
Transmitted Pulse with Average Ballast Insulation

With the RACO High Voltage Impulse Track Circuit* positive shunting is assured *regardless* of such conditions as rusty rails, lightweight equipment, disk brakes, heavy sanding and other common problems. The high inter-rail pulsed voltage breaks through wheel or rail film making the system ideal for use on track circuits from 50 feet to 10,000 feet in length. Add to this the almost complete elimination of foreign current problems by the use of an assymmetric pulse and "bridge" circuit relay.

RESULT — *Operating safety*, a must on any railroad, is increased through the dependable shunting of this reliable track circuiting technique.

*Manfuctured & sold by RACO under license from Jeumont-Schneider (France)

GENERAL LAY-OUT OF THE TRACK-CIRCUIT.



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Contact the RACO GROUP office nearest you for complete details

RACO PRODUCTS® ENGINEERED FOR LONG LIFE

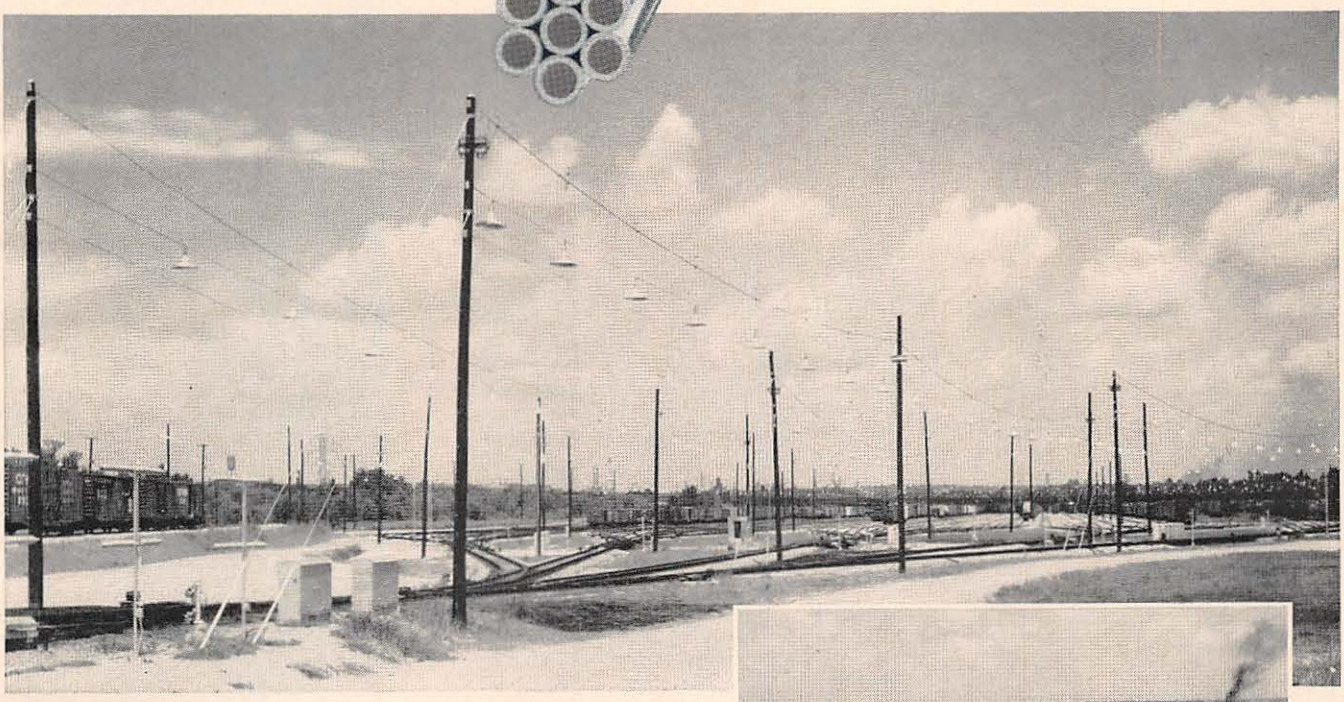
Railroad Accessories Corporation

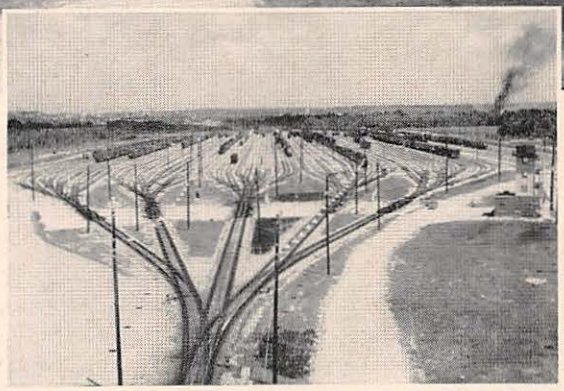
Main Office and Plant: 4650 MAIN STREET N.E., MINNEAPOLIS, MINN. 55421
Office and Plant: 7615 NATIONAL TURNPIKE, FAIRDALE, KY. 40118

IN CANADA: Vale Enterprises, Ltd., 352 Dorval Ave., Dorval, Quebec

Circle 51 on reader service card

The Alumoweld® Strand Supporting These Catenary System Lights Will Never Be Weakened By Corrosion





Southern Railway System's new marshalling yard at Macon, Georgia.

Alumoweld strand is designed to stand the test of time

Southern Railway System will never have to replace the guy and messenger strand on the catenary system supporting the hundreds of overhead lights in its new marshalling yard at Macon, Georgia. That's because the strength of Alumoweld® strand is permanent. The thick aluminum cladding—guaranteed to be no less than 10% of the radius of each wire—prevents corrosion of the steel core.

On any overhead line or catenary installation, strand is a small part of the total cost—unless it must be replaced. To protect your investment in such installations, use Alumoweld—the strand designed to stand the test of time. Write today for Engineering Bulletin E D. 3000.

World Leader In Bimetallic Wire

COPPERWELD STEEL COMPANY

WIRE AND CABLE DIVISION, GLASSPORT, PA. 15045

For Export: COPPERWELD STEEL INTERNATIONAL COMPANY, New York

ALUMOWELD®

strand

...for ***supporting cables***

...for ***guying towers and poles***

Circle 54 on reader service card

Circle 55 on reader service card

Will it detect hot roller journal bearings?

Yes, we find them every day. And Servosafe® does it better than other detecting devices, too.

While it is true that the hot box incidence rate is lower for roller journal bearings, hot boxes still occur. And when they do, they approach a critical condition faster. The roller bearing disintegrates rapidly, without the time lag common to friction bearings. Your detector must spot the hot bearing fast. And the fastest way for you to spot it is at the source.

For the detector to sense heat at the wheel hub, side frame or arch bar, the heat has to dissipate—and that takes time—time you don't have with a hot roller journal bearing.

Servo reads what is actually happening —*when* it's happening and *where* it's happening. We read the heat at the source. After years of research and field testing, Servo selected its "slant-aspect viewing" design as the most efficient and reliable method of scanning. It is patented and exclusive with Servo.

The scanner's line of sight is focused at a relatively small spot on the side of the journal box. As the train moves away, the spot moves upward and inward along a diagonal line. If the train is approaching, the path is the same, but the spot moves downward and outward with the movement of the train.

A Servosafe Hot Box Detective System is your answer to the hot roller journal bearing problem. Your answer to efficient and reliable hot box detection. Write us today with any questions pertaining to *your* system.

What about service?

In essence, you get the service you need wherever and whenever you need it. For example, the Hicksville headquarters of Servo's Railroad Products Division maintains a completely staffed Application Engineering Group. These Servosafe® specialists will study your operations and help your personnel in planning the type of Servosafe Hot Box Detective installations you need right from the beginning.

Next, Servo always furnishes field engineering services to assist you through the initial startup of your systems. Complete instruction manuals are provided for your staff, and Servo will train your personnel in system operations and procedures. This training can take place at a location on your railroad.

The course comprises operation, maintenance, servicing and trouble shooting all components of the Servosafe systems. Servo school graduates have the knowledge and competence that enable low-cost, efficient system maintenance.

And Servo field engineers are ready to help you with on-the-spot service in any way they can. Servo can always get skilled help to you—fast—when you need assistance. As for repairs and spare parts, Servo takes pride in handling and shipping them promptly and efficiently.

So, if it's a question of service, we've got the answers.

Protected under one or more of the following U.S. Patent Nos.: 2,880,309 and 2,963,575. Other U.S. and Foreign Patents Pending.

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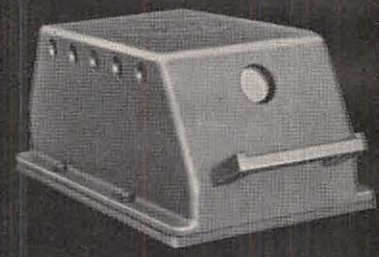
The Servosafe® Hot Box Detective System



Write for a free brochure on the Servosafe Hot Box Detective—the electronic journal bearing monitor that cuts railroad operating costs. Servo corporation of america, 111 new south road, hicksville, new york 11802, 516-938-9700

servo

September 1967
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EDITOR'S CORNER

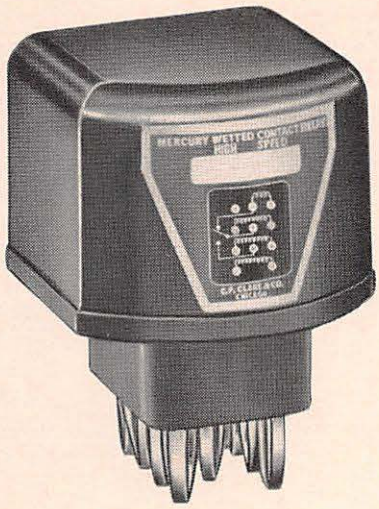
Recently the question came up as to whether it was more economical to buy new equipment or to build your own out of components. Also pertinent to this is the choice of rebuilding equipment when it wears out or replacing it with new equipment. The major argument for "do-it-yourself" and rebuilding is that it costs less. As to out-of-pocket costs, there is much to be accurately determined. For example, can the railroad buy in sufficient quantity to obtain components and materials at low prices? Also, is the railroad employing labor that could more profitably be used elsewhere. The old "saw" that the men are on the payroll, so they might as well be building or rebuilding equipment might not stand up under close examination. It might be more economical to phase out this "do-it-yourself" operation. On these "do-it-yourself" projects, overhead such as supervision, heat, light and housekeeping of the facilities should be included in determining costs.

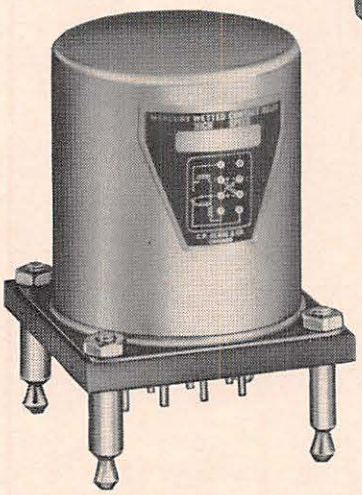
As for buying new equipment, the major advantages are a quality product including reliable operation, and the opportunity for railroads to benefit from research and development devoted to improving technology. As for quality and reliability, manufacturers have employees skilled in assembly techniques and quality control is an added function. Manufacturers also back their products, usually through warranties, written or implied. Very few railroads are doing or have done any research and development work in signaling or communications. But manufacturers have expended much money, manpower and know-how on R&D in these areas. Additionally, new equipment costs are usually lower than "do-it-yourself" built equipment because the manufacturer has lower production costs (he can mass produce, and buy in large quantities).

As to costs—total including initial price or outlay, plus operating and maintenance—I believe that a complete and true analysis will show that it is really more economical to buy new equipment.

Bob McKnight

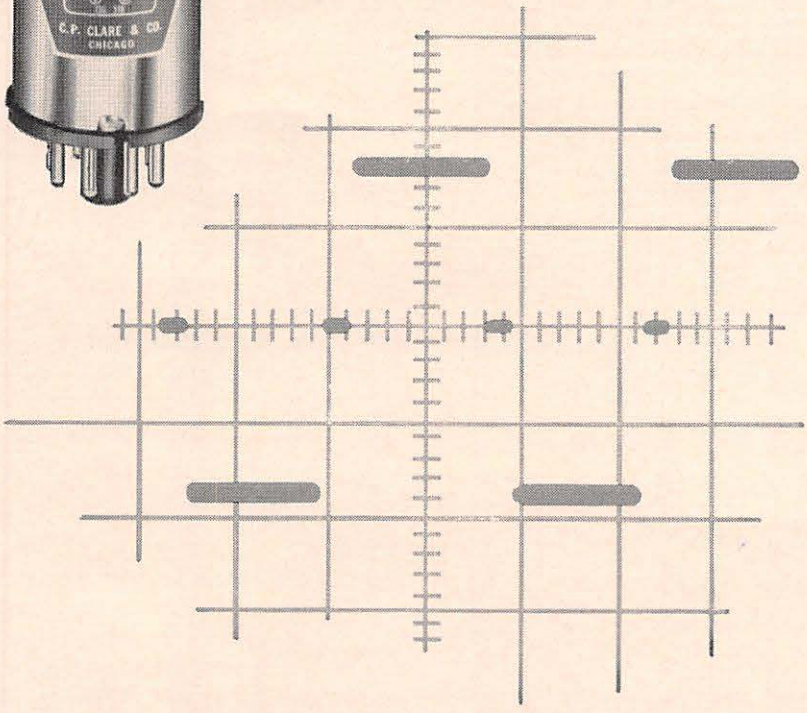
CLARE/Optimity in control





◀ **Direct replacement units** for use in existing telegraph/teleprinter circuits

◀ Models for wired assemblies ▶



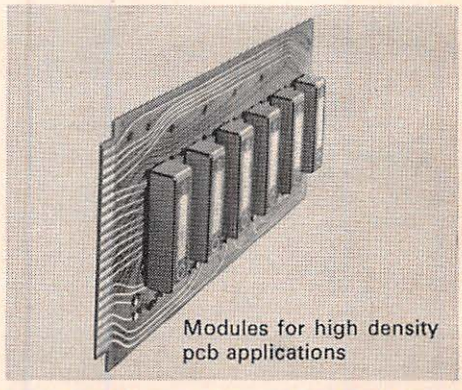
no bad orders,

over years of service—Clare Polar Relays provide over 22 billion operations without maintenance or adjustment!

Clare Mercury-Wetted Contact Polar Relays more than pay their way in maintenance savings... sealed-in-glass contacts end the cleaning and adjustment costs of standard polar relays. You gain better performance, too. Clare Polar Relays deliver clean-cut, sharp outputs all along the line . . . with minimal pulse distortion over billions of operations . . . at speeds to 180 baud (90 cps) with signal unbalance of 2% or less. Put new performance efficiency and savings to work... make unit-for-unit replacement in present telegraph/teleprinter circuits . . . specify wired assembly units, and exclusive Clare pcb modules for advanced communications and computer operations.

For complete information, circle reader service number—or ask Clare for Bulletin 853A . . . Write Group 9X8

C. P. Clare & Co., Chicago, Ill. 60645



Modules for high density pcb applications

- Maximum 1% pulse distortion initial, 2% over life (22×10^9 operations) with no maintenance
- Low and constant contact resistance, completely independent of drive level
- High contact efficiency . . . 95% total dwell, compared with 85% in other polar relays
- Withstands 1500 volt line surges
- Lowest cost over longest life

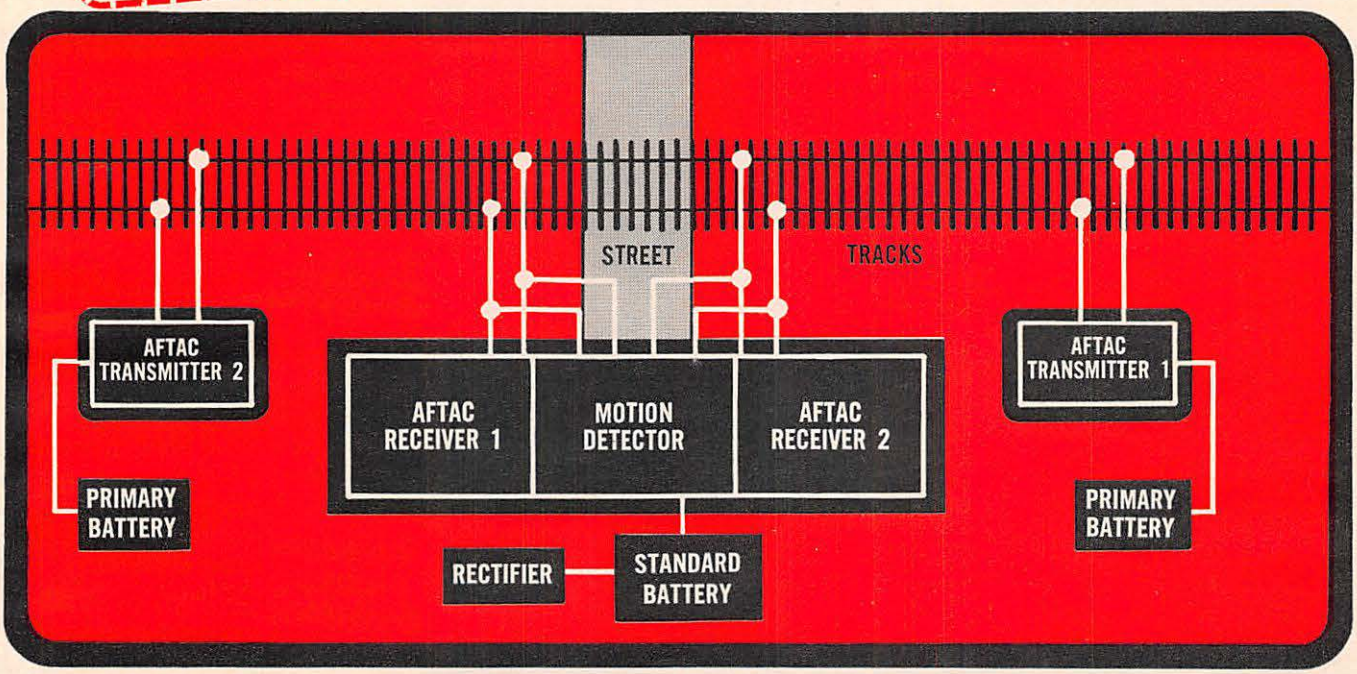
CLARE MERCURY-WETTED CONTACT POLAR RELAYS

for digital data transmission, telegraph and teleprinter service, impulse repeater, computer input and output circuits, polar signalling

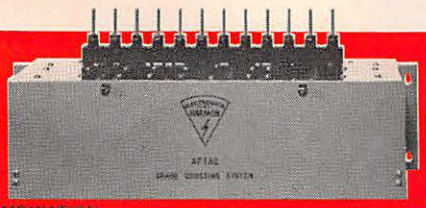
Circle 56 on reader service card

NEW PACKAGING CONCEPT

NOW! Get increased economy and efficiency from Harmon's motion detector and receiver combination.



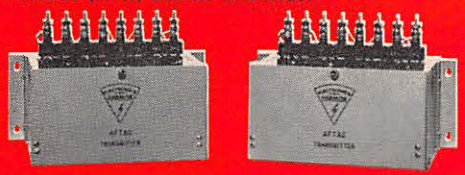
How Harmon's 1150 A Audio Frequency Train Activated Circuit System for grade crossing protection works: 1140 A motion detector and two 1100 AR receivers combined in one package, plus two 1100 AT transmitters make up system.



COMBINATION

Motion Detector detects approaching train, all train starts and stops, within 2400 feet (depending on train speed). Built-in, adjustable island circuit from 10 to 2400 feet. All silicon solid state. Receiver ring-by: 5 feet or less, even under extreme ballast conditions.

All units have built-in surge protection; 23 channels between 500 Hz and 10.2 KHz; environmental stability under extreme temperature range; require no insulated joints, shunts, or chokes.



TRANSMITTERS

Transmitters use low input current (70 ma @ 12 V with 2 ohm load). Shunting characteristic of 20 feet maximum.

Call or write Harmon Electronics for the full story. See how much you save on this new combination of proven units. And see how much you'll save on maintenance. (Transmitters use low input current and throw-away batteries.) It's Harmon's newest, practical step toward simplifying one problem of modern railway signaling and communication.

Harmon's personal service policy will save you time.

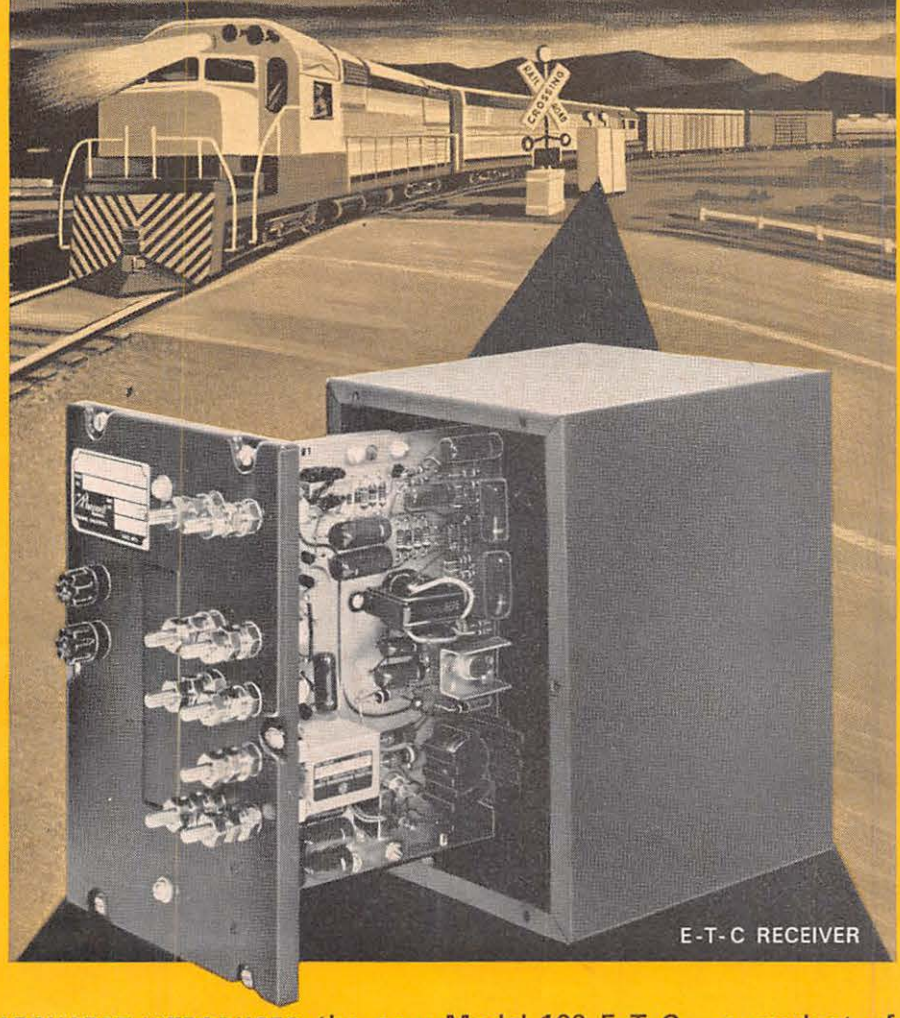
Herman is never too busy to answer questions, find solutions, or come through for you when speed is important. Call or write:

HARMON
ELECTRONICS, INC.
Grain Valley, Missouri
Telephone: Area code 816, 249-3338

Circle 57 on reader service card

from Marquardt Industrial Products

THE NEW LOW-COST MODEL 100 E-T-C



E-T-C RECEIVER

MARQUARDT INTRODUCES the new Model 100 E-T-C...a product of advanced electronic engineering technology for improved, low-cost overlay track circuit applications. ■ Marquardt's Electronic-Track-Circuit system...with records of proven reliability and fail-safe operation in more than 500 installations—is now available in a *new design at lower cost, with improved operational and maintenance features.*

MEET THE NEW MODEL 100 E-T-C

- *Burial shunt requirements eliminated!*
- *Power consumption significantly reduced!*
- *Remote transmitter operable from primary batteries!*
- *Operating band expanded to 11 frequencies!*
- *Simplified modular transmitter and receiver packaging for ease of installation and maintenance!*
- *Shunting characteristics improved!*

Also ask your Marquardt representative about the new Modulated Electronic Track Circuit (METC) for use in A.C. coded cab territories and the new EMETC for use on electrified railroads.

MARQUARDT INDUSTRIAL PRODUCTS

SYSTEMS AND COMPONENTS TO SERVE THE RAILROAD INDUSTRY

Marquardt offers an expanding product line and diversified services to meet the continuing demand for modernization by the railroad industry. Call upon Marquardt for new systems and components for improved, efficient service at lower operational and maintenance costs.

Railway Signals & Controls
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Pomona, California

- *Grade Crossing Predictor Systems (GCP)*
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R. W. Neill Company, Inc.
4320 W. Montrose Avenue
Chicago, Illinois

- *Communications Systems for Railway Classification Yard Applications*
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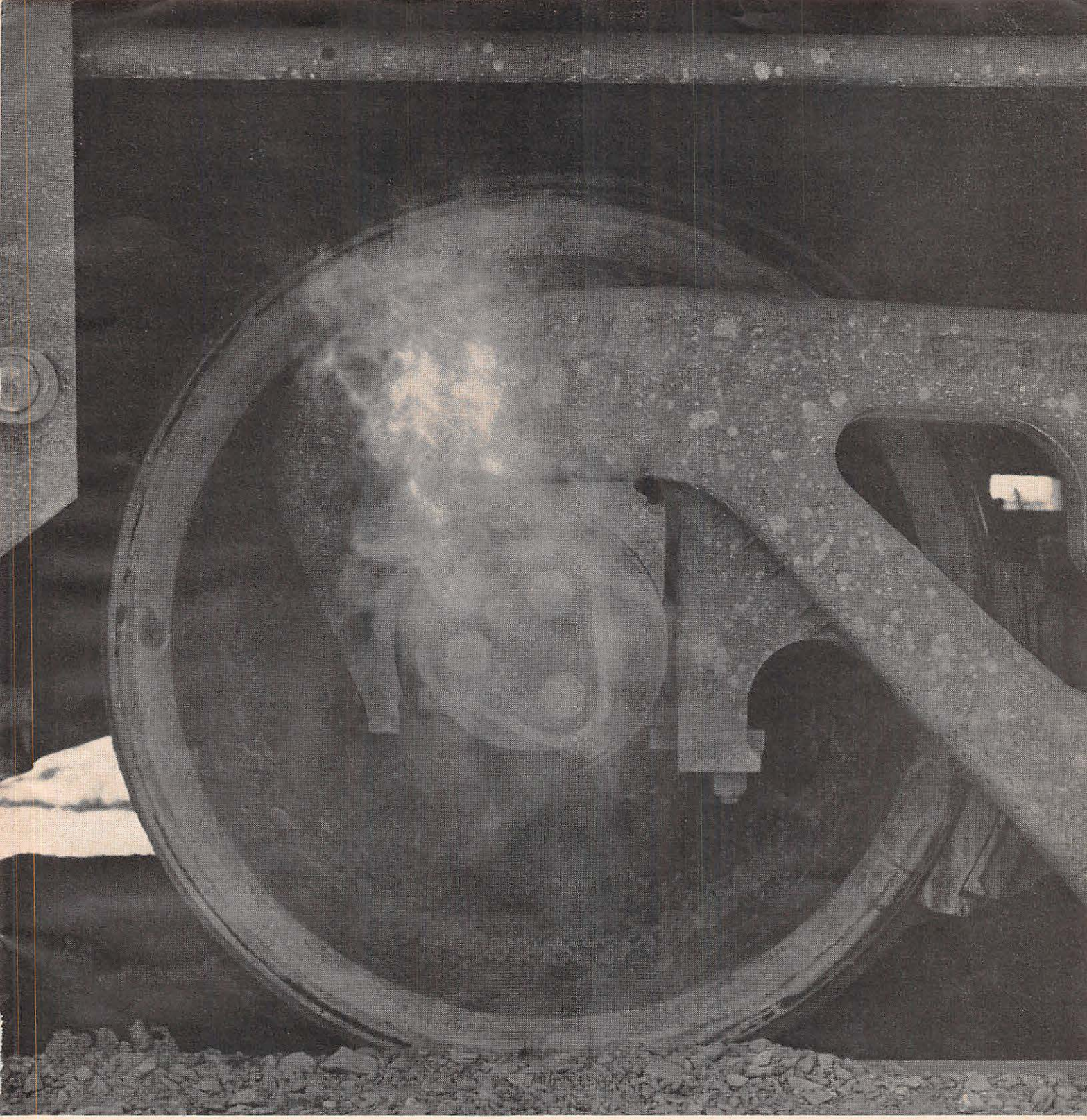
MARQUARDT INDUSTRIAL PRODUCTS

Circle 58 on reader service card

Circle 59 on reader service card



Out of the money.

Literally. It costs millions of dollars a year, plus the lost railroad tonnage cars can't carry. The culprits: hot boxes, disintegrated bearings, axle burn offs.

Solution: a hot box detection system, sensors, data transmission equipment, recorders. *We make the transmission equipment.* We call it the Lenkurt 960A. It accepts input from all detector units and transmits it to your recorders. Use the 960A with all transmission media from open wire to microwave radio, at any of 27 carrier frequencies. It maintains a constant high level of reliability over a long life and meets all AAR operational standards.

No matter what your needs: readout to train crew, dispatcher, car inspector, or a combination, a 960A puts the signal through. Write for complete information on the 960A. It will help keep your cars rolling in the money. Lenkurt Electric Co., Inc., San Carlos, California. Other offices in Atlanta, Chicago, Dallas, and Stamford, Connecticut.

LENKURT ELECTRIC

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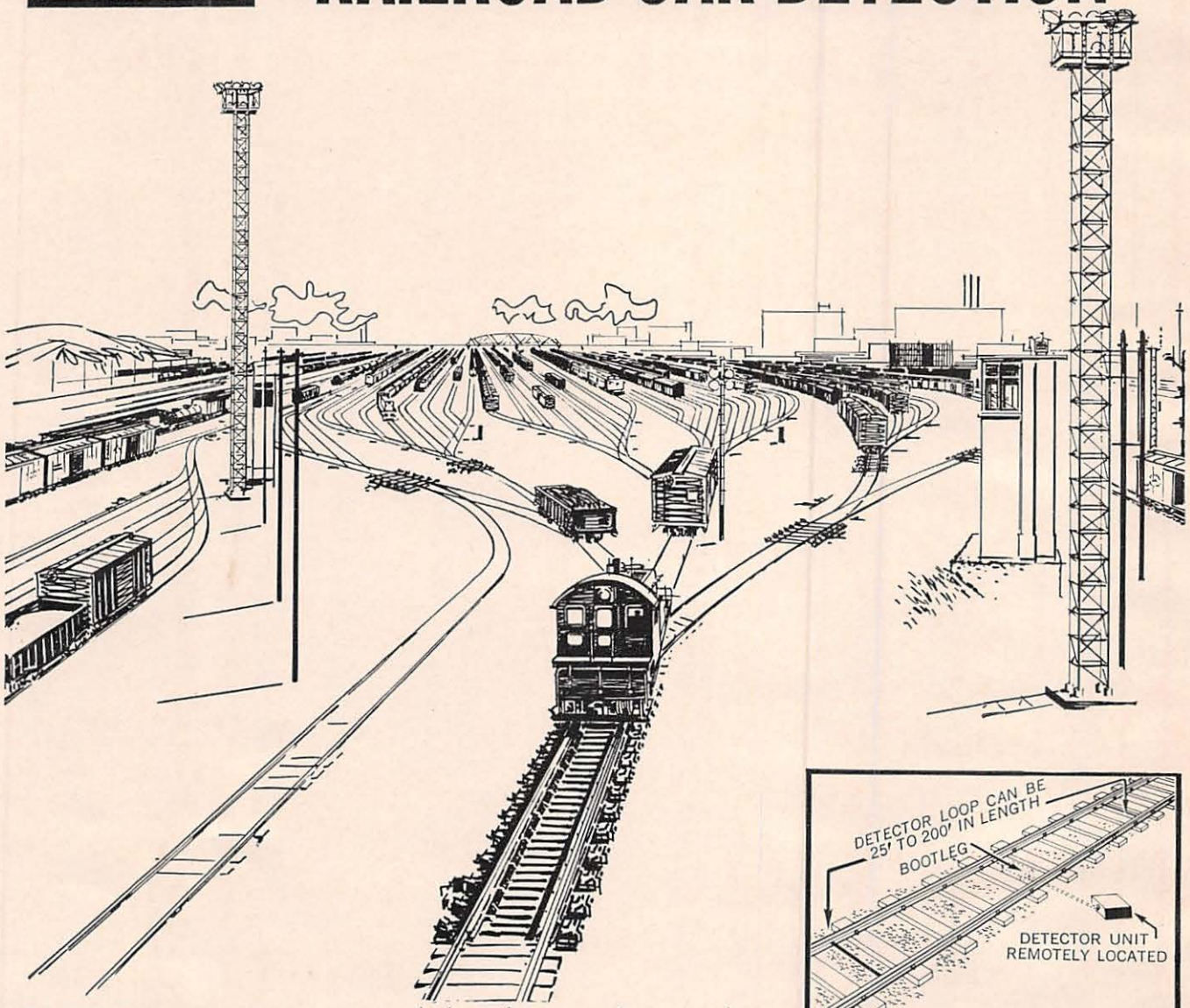
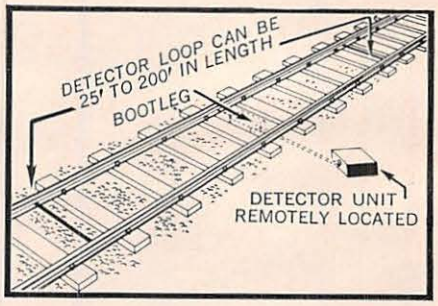
GENERAL TELEPHONE & ELECTRONICS

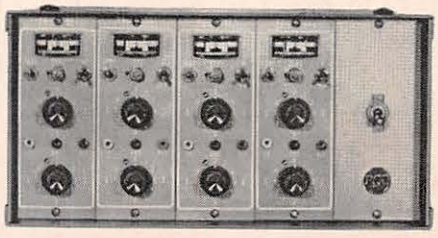
GENERAL SYSTEM

RCA
INDUSTRIAL AND AUTOMATION PRODUCTS

RAILROAD CAR DETECTION







This 11½" x 9½" x 5½" enclosure contains four detectors and a power supply. It can simultaneously detect the presence of cars at 4 different locations, up to 1000' away.

RCA "VE-DET" . . . reliable . . . easy to install and maintain . . . a unique electronic device, which uses the track itself to form an inductive detection loop." Provides safe, true presence detection (as long as a car is over a predetermined length of track). The loop can be from 25 feet to 200 feet long and is not affected by cars on nearby tracks. With VE-DET, switch signal cannot be given until car is completely clear. Installation is simple. No alteration or special insulation of the track is required.

VE-DET utilizes all solid state plug-in modules—easy to maintain and highly reliable. The loop is unaffected by track circuits or environmental conditions. And no above-ground structure is required near the track.

VE-DET Railroad Car Detection System is the outgrowth of extensive research and development by RCA in the field of motor vehicle detection. Hundreds of installations for highway traffic counting and control have already proved the exceptional dependability and accuracy of these units.

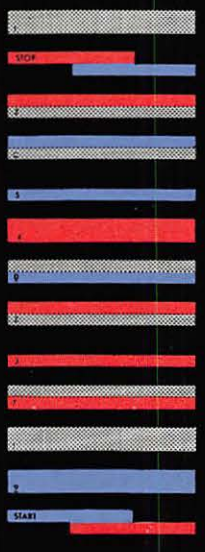
For further information write RCA Industrial and Automation Products, Dept. B-248, 41225 Plymouth Road, Plymouth, Michigan.

The Most Trusted Name in Electronics

Circle 60 on reader service card

Circle 61 on reader service card

KARTRAK* ACI is the only operationally proven ACI system



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*Trademark

NEWS BRIEFS

• BELT RAILWAY OF CHICAGO: has ordered 132 Hevi Car Kits from the Signal & Communications division of WABCO to increase retarder tonnage capacity. This involves replacing the 12" cylinders used on earlier WABCO retarders with 14½" cylinders and extra springs.

• BURLINGTON LINES has taken the squeal out of its inert retarders at the bowl end of Cicero, Ill., retarder classification yard. When pulling the class tracks, the 3,000 Hz squeal often reached 200 db, which brought complaints from nearby residents. The solution was to construct a ductile iron and graphite insert which is slipped lengthwise into the ball of the retarding rail. Not only is the sound down to a dull rumble, but the ductile iron and graphite insert provides better retarding effort than the previously used all-steel rail.

Burlington is working directly with D&RGW, GN, NP, NYC, PRR and UP to provide up to two hours' notice of cars being interchanged.

• CENTRAL ILLINOIS LIGHT CO. has ordered a radio remote control system for a locomotive from the Signal & Communications division of WABCO. The system will be located in Peoria, Ill.

• ILLINOIS CENTRAL has purchased type J centralized traffic control equipment from General Railway Signal Co. to control 27 locations on their mainline between Rath, Iowa and Lena, Ill. Control will be from a machine located in Waterloo, Iowa.

• KANSAS CITY TERMINAL will spend $4.6 million to consolidate 11 interlocking plants and for track changes. Signal & Communications division WABCO will design circuits, supply equipment and make installations. Kerite Co. will supply wire and cable. The project will take three years to complete.

• NEW YORK CENTRAL has equipped 33 diesel and electric locomotives with two-way radio which operate in suburban-commuter territory near New York City. Also, seven wayside base radio stations were installed to provide communications between train crews and the dispatcher.

• KANSAS CITY SOUTHERN recently installed two Servo Corp. hotbox detectors with associated FM carrier equipment.

• NORFOLK & WESTERN has ordered three hydraulic retarders from General Railway Signal Co. for pier 5 at Lamberts Point, Va.

• NORTHERN PACIFIC has placed an order with General Railway Signal Co. for type E2 centralized traffic control equipment for installation on about 30 miles of mainline between Castle Rock and Wabash, Wash.

• PASSENGER TRAIN mobile telephone service will be provided on the high-speed ground transportation test trains operating between New York and Washington. The new equipment has been designed by Bell Telephone Laboratories and will include special versions of multi-channel mobile radiotelephone equipment built by General Electric's Communications Products Department.

The new GE equipment, which will be for trains operating up to 150 mph, will help keep passenger communications properly channeled although land line interconnection points for radiotelephone calls from the train may change several times en route.

Units ordered by the Bell Telephone System will be installed in parlor and coach-snack cars. Fast-acting automatic channel identification and an electronic channel searching device in the GE mobile radio unit will operate with other train telephone equipment to provide convenient dial service with land locations.

The experimental radiotelephone system will operate in the 406-420 MHz frequency band and will incorporate special crystal filters.

When a call is made, logic circuits in an oscillator search board work with the train's mobile electronics and automatically scan selected channels for an idle circuit to reach geographically-spaced base stations. Quickly selecting an available channel, the search device in the GE equipment locks on it by means of an electronic command from the supervisory logic. A new 10.1 MHz intermediate frequency crystal filter in each mobile unit permits the use of a single oscillator for both reception and transmission.

The passenger is provided a warning signal well in advance of leaving certain radio zones where radio channels are not available. The oscillator search board also triggers the channel identification board providing an automatic voltage to a track location identification system in each telephone-equipped car which determines channel availability in the next zone. Coils mounted between the track rails at strategic points serve to identify zones to the car-carried identification equipment.

• SAN FRANCISCO BAY AREA RAPID TRANSIT DISTRICT has ordered eight complete automatic car identification systems to identify and record car numbers as they pass selected locations. This information will be used to log car mileage and establish car maintenance schedules.

• TEXAS & PACIFIC–MISSOURI PACIFIC has received DOT approval for the installation of a traffic control system on single track between Livonia and Plaquemine, La., a distance of approximately 29 miles. Control will be from Houston, Tex.

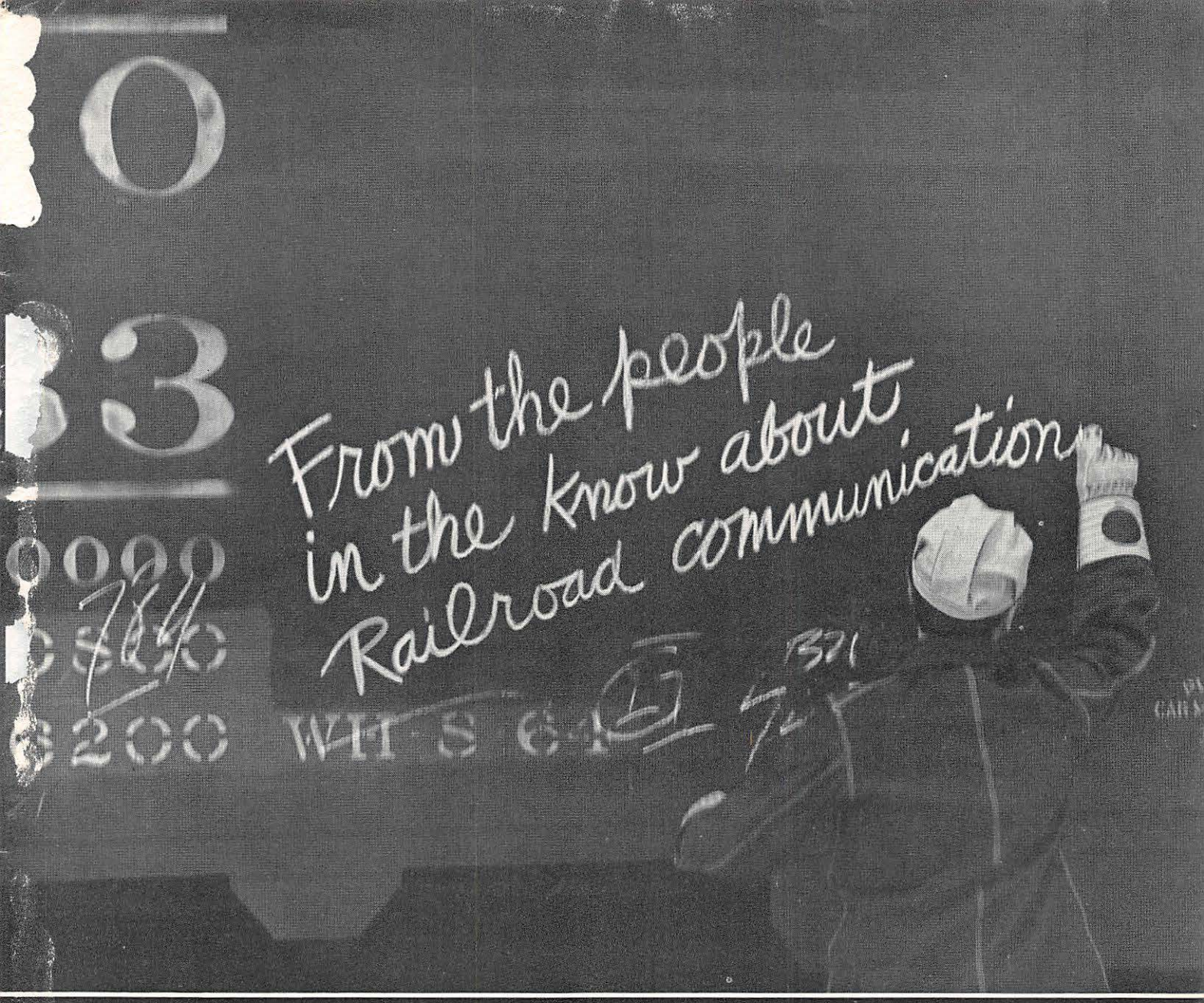
Railway Personnel

• AAR: A management systems department has been established to provide, among other management information functions, operation and control of the AAR's TRAIN system. (TeleRail Automated Information Network)

Carl L. Byham, former executive director, Data Systems Division, has been elected vice president to head up the new management systems department.

R. A. Petrash, assistant executive director, DSD, has been appointed executive director to succeed Mr. Byham. **V. G. Rymarowicz,** assistant to the secretary, DSD, has been appointed secretary succeeding **A. G. Hilley,** resigned.

(Please turn to page 37)



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RAILWAY SIGNALING and COMMUNICATIONS

Searchlight signals are added to provide reverse signaling on main tracks in the 60-mile commuter territory.

GO transit gets new signals

Signal changes included the installation of remotely controlled switch machines on switches and crossovers. More than 1 million ft of multi-conductor cable was used.

GO transit—the Canadian National's partnership with the Province of Ontario to provide commuter service in the Toronto metropolitan area—is now in full operation. For CN's signal department it meant considerable work. For example, six to eight signal gangs installed approximately 100 power switches, 35 signal bridges complete with multiple-aspect searchlight signals, over one million feet of multiconductor cable, and all the controls for a 60-mile, 4-track CTC project.

GO transit extends about 40 miles west of Toronto, Ont., to Hamilton, and 20 miles east to Pickering.

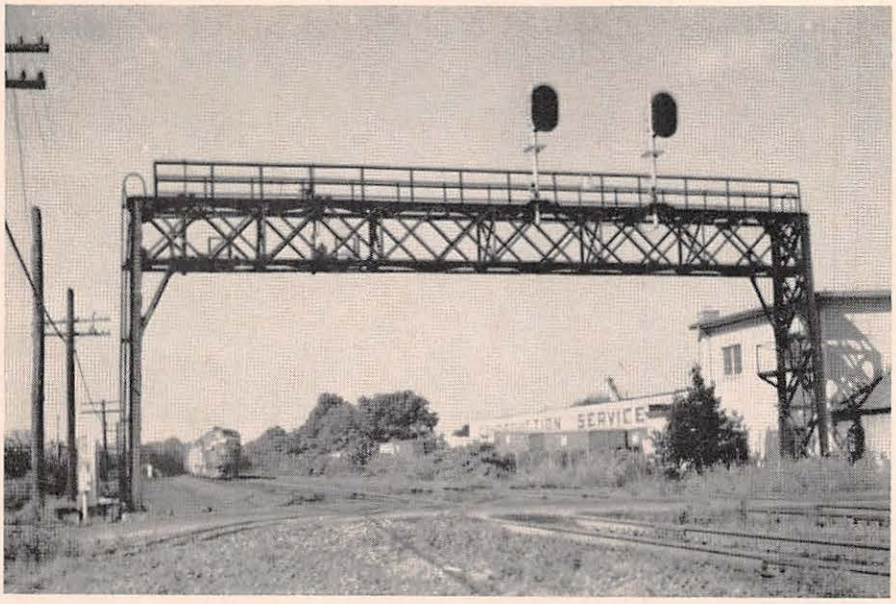
Officially known as Government of Ontario Transit, the commuter service operates 50 trains, Monday through Friday. At peak rush hours, trains operate on a 20 minute headway. In addition, CN has 32 regularly scheduled passenger and 14

freight trains operating in the territory. With extra trains, the daily total may well run over 100. Adding in locals and switch runs, the prompt handling of all trains could be a monstrous problem.

But thanks to alert signal engineers, keeping trains on time was solved by installing centralized traffic control. Between Pickering (east of Toronto) and Bronte (just east of Hamilton), the four tracks are reverse signaled. To provide for runarounds for fast trains catching slower ones, as well as effectively utilize all tracks, 17 interlockings were installed to provide access to any track from any other track.

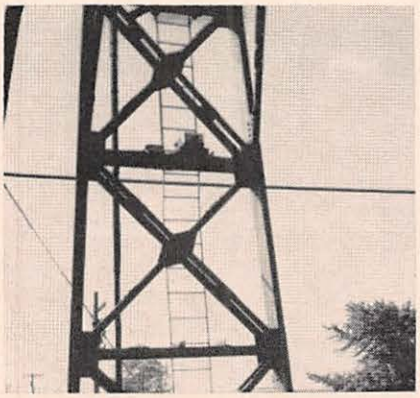
Control of the 59 miles of CTC from Pickering to Bronte is from a control machine at CN's Toronto classification yard administration building, 14 miles north of the city. Four men, each assigned a specific section of the line, operate push-buttons for control of routes shown on the 36-ft track diagram. A 2,000 bit per second code system handles controls and indications between the control machine and field stations.

From interlocking plant to interlocking plant, each train is assigned a running track through the Pickering-Bronte corridor. As it passes through a block, the light for that block on the track diagram is lighted an appropriate color to indicate the particular type of train in that block: red for commuters, flashing-red for conventional passenger trains, and white for other trains. Type-of-train information is inputted to the system by the operators. Green lights on the track diagram indicate the route. **RS&C**



High-load detector is at Middlesex, N.J. Alarm is sent 13 miles to Cranford Jct.

JCL detector spots moving high loads



Receiver has shutter to keep dust, snow and ice away from the sensitive cell.

Source beams light over tracks at 15 ft 9" above the top of rail.

Jersey Central Lines has had over 16 months' service from a high load detector at Middlesex, N.J., on its mainline. And it has more than paid for itself. "Within three months of its installation, a $3,350 electric eye clearance detector has been instrumental on several occasions in averting possible damage to freight ladings, equipment and overhead bridges which could have run to hundreds of thousands of dollars," reported CNJ's monthly paper *Newslines.*

The Railroad Accessories Corp., high load detector is mounted on a signal bridge at Cedar avenue. The light unit, mounted on the northside leg transmits a light beam at a height of 15 ft 9 inches above top of rail to a photoelectric cell mounted on the south leg of the bridge. If and when a high load breaks the light beam, the detector amplifier actuates a relay which causes a red lamp to be lighted on the interlocking panel at XC tower at Cranford Jct., 13 miles east. Detector actuation also causes an alarm bell to sound in the tower.

The detector is operative for all eastbound trains and sufficient time elapses from actuation until a train arrives at XC tower for the towerman to notify the Jersey City dispatcher. The train crew may be directed to stop prior to or arrival at Cranford Jct. to inspect the train. Trains may be rerouted to another mainline track at XC tower so as to pass under a PRR overhead bridge, or via Staten Island Rapid Transit tracks to bypass the PRR bridge.

The detector is turned on for eastbound trains only. This is effective when a train reaches a point 5,000 ft west of Cedar avenue and actuates

the automatic gates and flashers at the crossing. An electric shutter protects the photo-electric cell against dust, snow and ice when not in operation. The shutter opens when the detector is turned on by an eastbound train.

Lee C. Moore, signal and communications engineer, and assistant signal engineer William J. Yanega solved the problem of detecting high loads for this CNJ location. They utilized existing underground cable for transmitting detector alarms to XC tower at Cranford Jct. However, a two-mile stretch of open wire lines intervened in the 13-mile transmission line. Rather than installing two miles of underground cable or add open wire over this distance, they installed a line overlay. An AC overlay circuit was superimposed on an existing signal circuit open wire pair.

Speaking of detectors, CNJ has four locations where electric snow detectors automatically turn on switch heaters to keep power switches free of snow and ice. Two locations are at ends of double track and the other two are at ends of a controlled siding in CTC territory.

In a matter of seconds after rain or snow starts falling on the detectors when the temperature is 35 deg. F or lower, the detectors activate propane gas heaters located at the switch points. If for any reason the heaters do not light within 30 seconds after the detectors turn them on, the controlling valve automatically shuts off the flow of gas from nearby storage tanks. **RS&C**

Railway Cybernetics

ATO at Expo 67

At Montreal, Que., the Expo Express is carrying some 30,000 passengers per hour along its 3.7 mile line. There are eight 6-car trains operating on a 2.5 minute headway. Control and operation is automatic, the equipment being furnished by the Signal and Communications division of WABCO.

To start the train, an attendant on board pushes a door-close button, and then pushes the automatic train operation "go" button, and the automatic apparatus takes over the running controls. The train accelerates to maximum permissible speed, slows for curves and stops at pre-determined station locations. The attendant pushes a door-open button. The cycle is then repeated for further train movements.

Basic control apparatus includes a cab signal and speed control system without wayside signals or trip stops. Because this system uses low voltage audio frequency track circuits, it does not require insulated joints except in switching areas.

The control apparatus consists of (1) a wayside block system to provide speed-distance control between trains and terminals; (2) train-carried equipment to receive and indicate control intelligence transmitted through the rails by the wayside; (3) a voice communication system and visual signal and speed indicator panel located within an attendant's cab; and (4) a newly designed velocity control programmer that augments the basic signal and control apparatus to provide automatic operation.

The VCP, a servo-mechanism mounted in the cab of the train, automatically initiates applications of propulsion power and braking as they are called for by the cab signal and speed control system and the wayside controls.

Should any mal-function occur in the automated system, the attendant on board the train can take over instantly with manual controls. Also, failure of any single element results in immediate restrictions on the system to assure complete passenger safety.

At each end of the system, track stub-end terminals with diamond crossovers are provided. Interlockings are automatically controlled in that approaching trains have their station berths selected and switches positioned for movement into and out of the terminal. This allows maximum passenger loading and unloading time at minimum train intervals.

An operations control center at the Expo entrance is the heart of the system. An illuminated panel shows the route and progress of all trains. From here the supervisor monitors the whole system—including automatic dispatching, terminal interlockings, switches and crossovers—from a small control console.

The master dispatcher is thus able to check the complete train network and override the automated systems, in emergencies. He is also in contact with train attendants, as well as station, yard and maintenance personnel by radio, including walkie-talkies.

FCC lets tty rates lag a bit

The private line/Telpak tariff revisions went into effect August 1, 1967. However, the proposed teletypewriter station equipment rate increases were postponed for one year at the request of the Federal Communications Commission. American Telephone & Telegraph and Western Union agreed to an informal FCC request to defer voluntarily for one year the station rate changes.

According to *Telecommunications Reports*, "the revised tariff schedules of AT&T, among other things, eliminate Telpak A and B rates, increase

private line telegraph rates, and allow certain changes in private line telephone rates which the company stated will not affect the overall level of earnings for that service. Also included is a new broadband channel offering. Western Union's revised tariff schedules are along similar lines."

As to the remaining portions of the revised tariffs, which restructure the rate components applicable to the interexchange channels, and necessary terminals, and offer a wideband data/alternate voice service, the FCC said in allowing them to go into effect that AT&T has "undertaken to conduct a study in connection with the proceedings (in the general rate investigation) which will determine the level of earnings for each principal class of service, including the private line services here involved, on the basis of fully allocated cost and on the basis of market conditions as of Oct. 1, 1967. We believe that the data to be produced by such a study together with other data and rate structure evidence to be adduced in connection with the overall rate inquiry will afford a more definitive basis upon which to evaluate the specific rates for station equipment and channels."

In late July, the AAR filed a request with the Commission, along with the Great Northern, that the proposed Telpak tariff changes be suspended. New York Central filed a request that they be rejected or suspended. Specifically, the AAR said that the tariff changes represent "a clear and dangerous first step in the entire field of leased communications facilities by the railroad industry . . . There is no doubt that the proposed rate changes for Telpak C and D flow directly from the elimination of Telpak A and B, despite AT&T's claim that the changes were prompted by its conclusion that the Telpak market has not developed as it forecast."

Stating that many railroads have complex communications systems, the AAR said the situation is such that "a substantial number of roads are committed in some degree to sophisticated leased communications systems and can no longer deal on equal terms with AT&T.

"In other words, in 1960-61, when many railroad companies were considering the expansion of private communications systems, AT&T effectively persuaded a number of railroad companies to lease facilities instead. The railroads that scrapped their entire pre-existing communications systems in reliance on AT&T find themselves at a great disadvantage in dealing with that company, since they can no longer rely on the threat of turning to a private communications system as an effective means of insuring reasonable rates for the leased facilities. They are, in effect, captive customers."

Great Northern said it placed an order with AT&T in January for service based on Telpak C, after considering the possibility of a private microwave system. Now, its private line teletypewriter and voice services ordered at indicated rates of $57,600 per month will be increased to $63,530 after August 1. Meanwhile, GN has made so many commitments, it must go forward with the plan.

In its filing with the FCC to reject or suspend the tariff changes, New York Central said its costs will be increased by $147,000 a year or just under 25%. It agreed with the AAR that AT&T has failed to justify the teletypewriter rate changes in the material it has submitted to the FCC, and in the view that it is necessary to decide rate-making principles and factors in the overall telephone rate case before the projected changes can be made. **RS&C**

RR mergers can be good for S&C men

For signal and communications men railroad mergers bring problems, but they also bring advantages. In the problem area is the enormous demand for communications. Also, there is a need for standardization. There is usually an increased demand for capable personnel. On the advantage side is the broader base for positions, a better chance for promotions. Because the merged company is most often in a stronger financial condition, it is in a better position to seek capable personnel. With the better financial condition, the merged railroad is often able to increase spending for improved signal and communications facilities. In general, a merger is a beginning, not the end, for the signal and communications men.

This, in brief, is what Joseph G. Karlet, manager of signals and communications, Norfolk & Western, told his audience at the Eastern Sectional meeting of the Communications & Signal Section, AAR, in Washington, D.C.

Speaking about the N&W consolidation involving the Nickel Plate, Wabash and Pittsburgh & West Virginia, Mr. Karlet remarked that much was done in the area of standardization of materials and procedures. A procedure was set up to review one item at a time, and the final selection was made on the basis of picking the best of each of the three previous road's practices (N&W, NKP, WAB).

Speaking of personnel, he said that the merged company provides a broader base for positions. For example, in each former company there was only one position above that of assistant signal engineer. In the merged company, an assistant signal engineer can move up into any of six positions. The pay can't go anywhere but up, he remarked.

There is some increase in employment generally in the signals and communications department of the merged company because of increased expenditures. As for the greater N&W company, Mr. Karlet said that S&C expenditures have risen 100% since the merger.

Another benefit derived from the merger is that of improved job stabilization. This, plus the other benefits of improved S&C work and number of positions have done much to improve morale.

He said that in the first few months everyone is buried in paper work. The correspondence almost tripled, but it settles down to a rea-

sonable level.

Another result of the merger is that the highest wages and fringe benefits of the three previously separate companies are now applied to all in the merged company.

The biggest merger problem, said Mr. Karlet, is people. The solution is to satisfy the people who stay, those who move to different locations, and those who do different work. And there is the problem, that everyone must contribute to prove that the merged company can provide better service than each of the three separate railroads.

Another speaker at the Sectional Meeting, Kenneth M. Lockerby, engineer communications and signals, system, Pennsylvania, described some of the signaling changes required when the high-speed corridor trains will be running between New York and Washington. Generally speaking, trains will be operating at 110 mph. This has necessitated extending the approach circuits for crossing protection at 23 railroad-highway grade crossings between Wilmington, Del. and Washington, D.C. At nine of these crossings, automatic gates are now in service.

Mr. Lockerby said that 1300-ft overlay track circuits have been added to the approach circuits. Also, 300 ft in advance of these circuits is a transducer to provide a timing section to determine if the train is traveling 110 mph. Previously, these crossings were provided for 80 mph train speeds. A 30-38 second warning time is the goal for the new high-speed operations.

Some new No. 20 crossovers will be installed using 45-ft curved points. These will be satisfactory for 45 mph operation, and are so signaled. Point detection will be checked at the switch points and 30 ft back of the points. He said that the present spacing of wayside signals, plus the cab signals and train control will be sufficient for 110 mph operation. It is expected that the high-speed trains will be interspersed with present traffic. **RS&C**

FCC bureau wants to let MCI microwave in

Despite objections from American Telephone & Telegraph Co. and associate companies in Illinois and Missouri, the common carrier bureau of the Federal Communications Commission has ruled that Microwave Communications Inc., should be permitted to construct a privately-owned interstate common carrier microwave system between Chicago and St. Louis as "essentially a test case with national significance."

According to *Telecommunications Reports*, the FCC bureau said that "the instant proposal (MCI's application for permission to construct a microwave system) should be given a reasonable opportunity to become established and thereby afford the Commission an opportunity to observe the results and consequences of its operations in terms of the demand generated for its services, its ability to operate efficiently and profitably, and its effects upon (the carriers') operations. The extent to which MCI's expectations will, in fact, be realized and the experience derived from its operations will enable the Commission to determine whether or not similar filings by MCI and/or others would be favorably entertained in the future.

"The MCI hearing—as well as several other hearings before this Commission—has arisen because of the impact of advancing technology upon consumer demands for communications services and the structure of communications markets. Advancing technology permits the establishment of new services that will meet consumer needs and demands that previously had not been satisfied. Commission policy should endeavor to bring about market conditions that will facilitate the application of new technology and the full development of untapped markets."

MCI, the Commission noted, is attempting to develop a specific communications sub-market, which if successful should expand the total communications market. The spur of competition which MCI will bring into the market place, said the FCC, will be a healthy one. Also, "potential customers who cannot now afford (the existing carrier') charges are entitled to avail themselves of the alternatives offered by MCI."

The FCC's common carrier bureau reported that the specific market to be developed by MCI would be so small relative to the size of the markets of the existing common carrier telephone and telegraph companies "that it would be almost impossible to discern any significant public disadvantages."

Continuing, the common carrier bureau said: "Based on the evidence of record, we believe that there are communications requirements of the public that are not being met under present tariff offerings and that submarkets exist today which are not being fully exploited by the existing carriers. Although MCI's tariff offering would be similar to certain present offerings in many respects, it would offer greater flexibility and control to the subscriber."

The bureau took the position that "in addition to the prospect that a grant to MCI would open up new communications markets, it would also 'serve to create new opportunities for the manufacture and sale of computer services, hardware, software, and related equipment' and even contribute additional avenues to carriers connecting with MCI."

Various advantages could be seen for the consumer in the form of an opportunity to purchase communications services that provide him with increased control and flexibility at an overall cost alleged to be substantially lower than he would have to pay if he subscribed to the closest alternative service provided by the existing carriers.

It was the bureau's position that "the existence of duplicate facilities is not necessarily contrary to the public interest."

Additionally, the Commission said that "MCI should be afforded an opportunity to demonstrate that its proposal is feasible, i.e., construction and operation of a system with 99.9% reliability without incorporating therein every feature that (the existing carriers) think appropriate." **RS&C**

DATA vs VOICE:

How data affects

By Robert F. White
Staff Engineer
Lenkurt Electric Co., Inc.

Voice transmission is still a vital necessary part of almost any communications system. Indeed, the added data communications requirements seem, if anything, to generate a need for even more voice channels, though perhaps there is no causative connection. For many reasons, most of them coming back eventually to economics, data transmission and voice transmission are likely to continue—for some years at least—to share the same communications systems. So the question of adapting the communications systems to take care of the data requirements, and to some extent adapting the data communications to fit into the characteristics of the communications systems, is one of considerable significance to communications users and equipment manufacturers.

The "communications systems" to be considered will be the types in common use today or likely to be put into use in private systems within the next very few years. In effect, this means carrier systems operating either over microwave, or over physical facilities such as open wire or cable. And "data" will be taken in general to include any information other than voice or voice associated signaling. It would thus include such things as multiplexed telegraph, telemetry, digital data in various forms and at various speeds, facsimile, and even television.

The common denominator is the nominal 4KHz voice channel, or standard multiples of it such as a 48 KHz block corresponding to a 12 channel basegroup and a 240 block corresponding to a 60 channel supergroup of the standardized SSBSC (single sideband suppressed carrier) frequency division multiplex pattern. For slower speed service such as telegraph, the voice channel itself is subdivided into a number of narrow band channels.

The adaptation of data transmission equipments to these well established and standardized frequency division blocks has already resulted in a considerable measure of standardization, for example, 1200 or 2400 bit per second operation in a voice channel, 40.8 kilobit per second operation in a basegroup, and the various standardized submultiplex configurations for dividing a voice channel into a number of telegraph or data channels.

Most of the data with which this discussion is concerned is digital in nature, that is, it comprises a series of pulses. These pulses cannot be applied directly to a frequency division multiplex system but must be transformed into a signal which can be accommodated by such a system. The equipment which performs the transformation is called a data modem or data set. At the transmit end, the modulator section of the data set uses the data pulses to key a subcarrier, usually either by frequency shift or by phase shift, (though sometimes by vestigial sideband (VSB)) and at the receive end, the demodulator section detects the shifts in the sub-carrier and converts them back into the corresponding data pulses. The simplest systems involve only binary, or two-state keying, for example, in a 1200 bit per second system operating over a voice channel the modem might emit a tone of 2400 Hz to indicate a mark or 1200 Hz to indicate a space. Higher speed systems often involve multistate keying such as ternary, quaternary, or duobinary, to get more information through a given amount of bandwidth.

Though differing in details, the telegraph type sub-multiplex equipments used for slower speed operations perform precisely the same sort of function, and can also be considered to be data modems.

The data modems or their equivalents are usually considered as belonging to the communications system, and the equipment to which they connect as belonging to the data processing system. Interface characteristics have been spelled out by the Electronics Industries Association in RS-232-B.

On the line side the data modems will be connected into the telephone multiplex system either at a voice channel point, basegroup point, or a supergroup point, as applicable.

The application of data to the system has two important consequences. One is that the system performance requirements for satisfactory data operation differ in some respects from those required for satisfactory voice operation. Parameters which are relatively unimportant for voice operation become quite significant when data operation is involved. Fortunately, most of the parameters which are important for voice operation are also of about equal importance to good data communication.

The other important consequence is that the loading applied to the communications system by the channels devoted to data may differ considerably from the loading that would have been applicable had the same channels been used for voice. Loading is a function of the signal power, and if the power applied to a channel by a data modem differs from the average power in a voice channel, the loading effect will of course be different.

Let us consider a typical communications system, with SSBSC multiplex operating over FM microwave. Some of the more important parameters which are typically controlled in such a system are listed below. Except where otherwise indicated, they will be referenced to a derived voice channel.

Channel bandwidth and frequency response: Lower limit at the 3 dB point typically 250 Hz to 300 Hz, and upper limit from 3,000 Hz to around 3400. In general, the wider bandwidths will allow higher speed data, or more sub-multiplexed telegraph type channels. When channels are connected in tandem the net

Editor's Note: Abstract of paper presented at Western Sectional Meeting of the Communication & Signal Section, AAR, earlier this year at Kansas City, Mo.

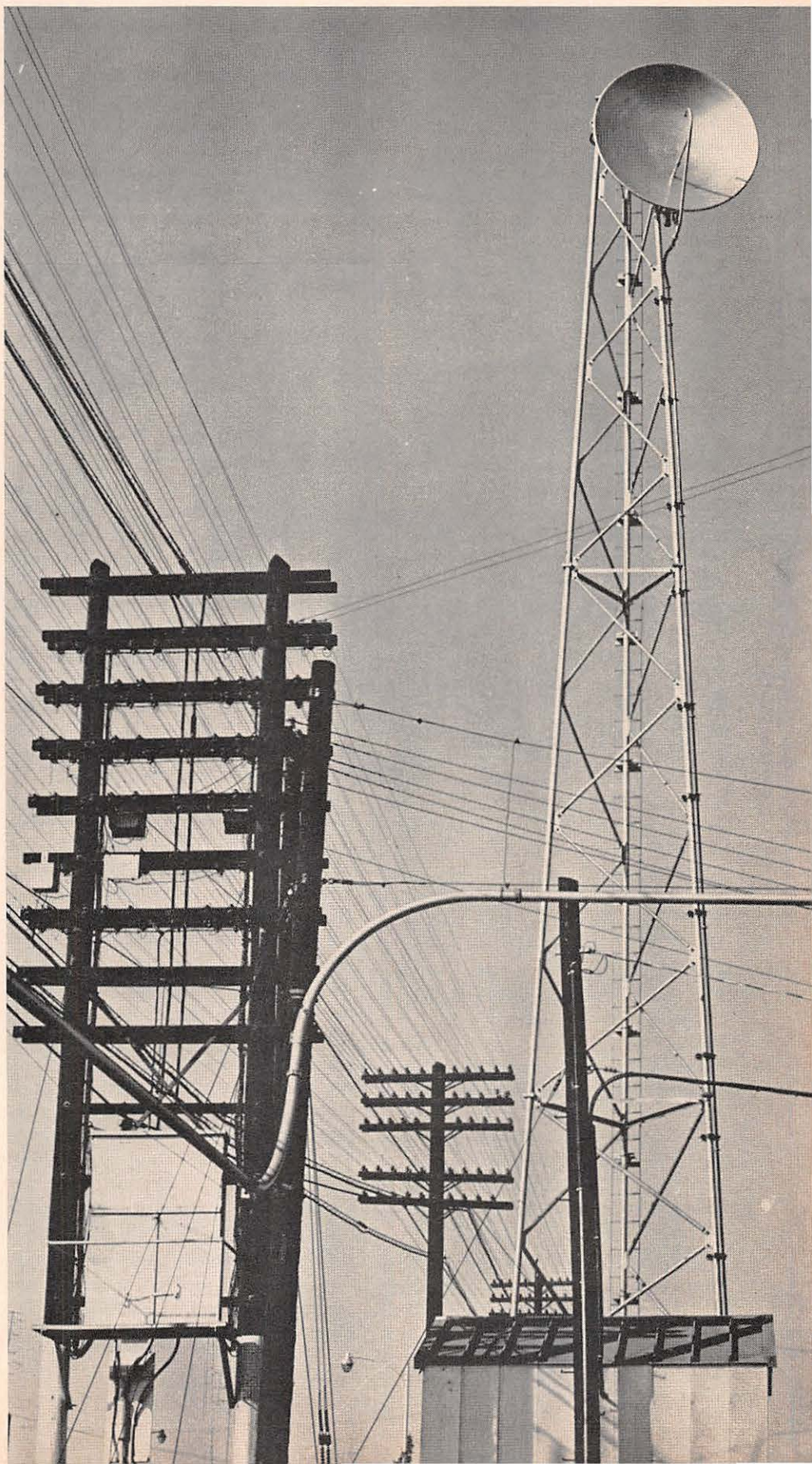
effect is to reduce the bandwidth overall.

Channel input and output levels: These are standardized for voice operation, and data modems must be designed to tie into these points with levels bearing some specific relation to voice test tone level.

Channel level stability: Stability adequate to meet modern voice channel requirements is adequate for almost all data applications. Frequency or phase modulated data systems are insensitive to amplitude variations, and for these systems the amplitude stability requirements are not as stringent as for voice operation, though changes in amplitude which also change the signal to noise ratio can affect the error rates.

Channel frequency stability: Requirements for data are usually considerably more stringent than for voice operation. Voice operation can tolerate frequency changes of 10 Hz or more without significant distortion. Most well designed high speed data systems can tolerate frequency displacements of 5 to 10 Hz. Narrow band systems may have tolerances of perhaps 2 or 3 Hz. Some data systems require zero displacement, that is, complete synchronization.

Random noise: Most of the noise developed in a multiplex channel on a microwave system is of the random or "white noise" type, spread more or less uniformly over the usable voice band. It consists mainly of thermal noise developed in the receiver, and intermodulation products developed as a result of the passage of the complex broadband signals through non-linearities in the various elements making up the system. Thermal noise varies inversely with receiver input level. Intermodulation noise varies with the system loading. For voice channel operation, two limitations are usually specified for random noise. One is an allowable noise level when the microwave paths are in their normal, unfaded condition, with the system loaded with the equivalent of its full capacity load. The other is an allowable noise level, considerably



higher, which the system can tolerate for very small percentages of the time; this second kind of limit usually corresponds to a deep fade on one path of the microwave system.

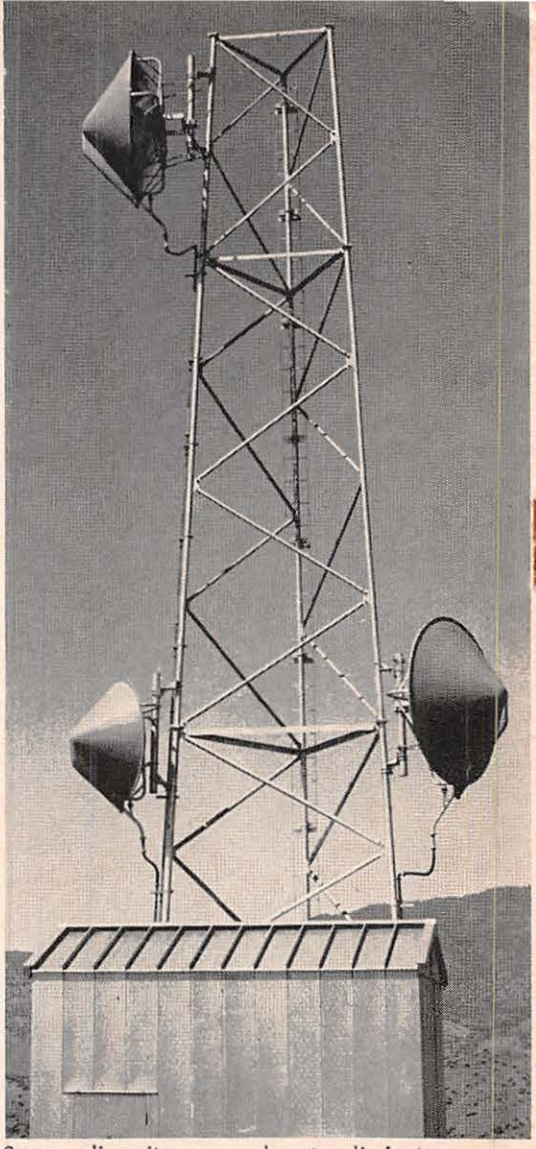
The first of these limits is a function of system length as well as equipment parameters. For short systems it might represent a signal to noise ratio in the voice channel in the neighborhood of 60 dB unweighted. For longer systems the ratio might be allowed to drop to 50 dB or even lower. The second of the limits is somewhat arbitrary, and is typically set somewhere in the neighborhood of 30 dB signal to noise ratio in the voice channel. It is independent of the length of a system, since even on a multihop system the chances of very deep fading on two hops simultaneously is vanishingly small.

These signal to noise ratios as described for a voice channel are really test tone to noise ratios, with the test tone being a 1,000 Hz signal at a level of 0 dBm0; the voice channel itself has no fixed level, but is statistical in nature with an average RMS power somewhere in the neighborhood of −15 dBm at the 0 dBm0 point of the channel.

The effect of white noise of this type on data systems is predictable, on a statistical basis, in terms of its effect on the error rate of the data system. The signal to noise ratio in a data channel will depend not only on the voice channel signal to noise ratio, but also on the bandwidth of the data channel itself and the relative level of the data signal with respect to test tone level. Narrow band telegraph type data channels, at commonly used levels, tend to be quite impervious to the effects of this kind of noise and can typically operate quite satisfactorily down below the lowest levels considered acceptable for telephony. For the higher speed data, using larger bandwidths and, in some cases, multilevel techniques, the noise of this type may establish a limit either on the transmission speed or on the error rate. For a given speed and type of operation, the error rate will go up as the random noise increases.

Impulse Noise: This type of noise, consisting of very short bursts which may reach quite high intensity, is of great significance to data transmission but of relatively little concern in voice transmission. The human ear is insensitive to noise bursts lasting no more than one or two hundred milliseconds, nor do bursts of this length affect the slow speed signaling circuits associated with voice channels. But the effect of such bursts on data can be devastating. Thus, a communications system which is perfectly satisfactory for voice transmission may need treatment to reduce impulse noise in order to make it satisfactory for data transmission. In fact, it was not until data transmission came into the picture than there was any realization that impulse noise did exist in considerable magnitude on the voice channels. Ordinary meters will not follow the very short bursts, because of meter damping. In order to detect them, it is necessary to use something like an oscilloscope or a specially designed impulse counter.

Delay Distortion: Here we have another parameter which is of great significance to data transmission and of negligible importance to voice transmission. Both types of transmission involve complex signals which contain components of many different frequencies. In an ideal system all frequencies would travel through the system at exactly the same rate so that they arrived at the receiving end in identically the same phase relation to each other that they had at the transmitting end. In a real system this desirable criterion is always violated to some degree, and the phase relationships may therefore be slightly different at the receive end. The ear responds almost entirely to the amplitude of the various components of a voice wave, and is insensitive to their phase relationships. Thus delay distortion in voice systems has not been of any great significance. But this is not at all true in data transmission. The waveform of the data pulse at the receive end is just as much dependent on the correct phase relationships of its various components as it is on the correct amplitudes. Relative delay is the problem, not absolute delay. If all components are delayed equally, phase relationships and waveforms are unchanged. The effect of delay distortion becomes much more significant at the higher data speeds. It is not much of a problem at telegraph speeds.



Space diversity can almost eliminate short, deep fades.

Short Period outages: For voice operation, occasional very short interruptions (on the order of a second or less) are of little consequence unless they are such as to cause a circuit disconnect. But for high speed data operation, an outage of a second could cause the loss of several thousand bits of information, and even outages measured in the milliseconds can cause errors in the data. Thus the reliability requirements, particularly in respect to very short interruptions such as might be caused by deep multipath fades, may be considerably more stringent on systems carrying data.

Of the parameters discussed above the ones which principally may require special consideration in equipment or systems design where data transmission is involved are: channel frequency stability, impulse noise, delay distortion, and short term reliability. But before discussing these matters in more detail,

I'd like to bring in the question of system loading, the relative levels used for voice and data, and some of the interrelated effects.

White noise equivalent loads: Communications systems of the type under discussion are typically designed to carry a specified number of voice channels at a load value which has been derived from statistical evaluations based on experimental data. The evaluation problem is a very complex one. A number of approaches have been used over the years, and although there are some differences in results, there has in the last few years developed a reasonable consensus around the CCIR formulas, and these are now being used almost universally in describing the equivalent load for a given number of voice channels and their associated signaling circuits. The formulas give the level of broadband "white noise" to simulate the loading of a given number of channels. They are expressed in terms of the RMS value of the equivalent white noise, applied over the same bandwidth as that occupied by the channels themselves.

One of the two CCIR formulas applies to systems with less than 240 channels. It calls for white noise loading of $(-1+4\ \log_{10}N)$ dBm0, where N is the number of channels. The other formula, for systems with 240 or more channels, calls for white noise loading at a level of $(-15+10\ \log_{10}N)$ dBm0.

The calculated loads are intended to give levels of white noise whose statistical peak values will be approximately equal to the statistical peak values of the actual multichannel load. The peak factor for white noise is usually taken as about 13 dB, that is, the peak level which is not exceeded for more than about .001% of the time is expected to be 13 dB above the RMS level.

The peak factor for multichannel voice loads varies with the number of channels. For a single channel it is about 18 dB, decreasing slowly as more channels are added until, at somewhere in the neighborhood of 200 channels, it levels off at a constant value of about 13 dB, the same as the peak factor for random noise.

White noise loading techniques to measure the noise performance of a system under busy hour loading conditions are well developed and standardized, particularly in connection with the radio portion of microwave systems. In fact, most basic system design is aimed toward providing optimum or near optimum balance between thermal noise and intermodulation noise under loading conditions derived from the above formulas. For example, a microwave system designed to carry a maximum of 600 voice channels would be designed to meet its noise performance objectives when loaded with white noise at a level of +12.8 dBm0, applied over a band extending from 60 KHz to about 2500 KHz. The value of +12.8 dBm0 for the white noise is calculated from the −15 +10 log N formula, and represents the equivalent load of the 600 voice channels whose average RMS value at the 0 test level point is −15 dBm.

We arrived at the equivalent white noise load figure by relating it to a certain number of telephone channels. But in another sense, the figure can be considered as a measure of the capability of the system to carry any kind of load, provided the load's statistics can be reasonably related to those of white noise.

As mentioned earlier, most types of data transmission involve continuous tones. The RMS power of a number of continuous tone data channels is simply their RMS power sum. When the number of tones exceeds about 15 or 20, assuming that they are not in some coherent relationship, the peak factor approaches the 13 dB peak factor typically used for white noise and for large numbers of voice channels. With smaller numbers of tones the peak factor decreases, down to 3 dB for a single tone. This is in direct contrast to the voice channel pattern, where the peak factor for small numbers of channels rises. The pattern for the two peak factors can be seen in Figure 1.

Data level selection: The discussion in the previous section points the way toward a method of determining the loading effect of data channels, in terms of their contribution to the equivalent white noise load.

To a first approximation, at least, it would seem that if enough voice channels and enough data channels are involved, we can begin to treat them in somewhat the same fashion.

We have already seen how, in fairly large voice channel systems, the RMS equivalent white noise power for full loading is −15 dBm0 per channel. Each individual channel must, of course, be capable of handling a much higher signal than this. For example, test tone level of 0 dBm0 is 15 dB above this average channel power. Also the channel must be capable of handling the peaks of "bull talkers" whose volume may be far above the average voice volume. It would be possible, at least in theory, to design all portions of this kind of multichannel system to handle all channels at maximum load simultaneously. But such a system would be economically grotesque. Instead, advantage is taken of the statistical characteristics of the multichannel voice signal to reduce the common equipment load requirements to practically realizable values.

It is most important to recognize this characteristic of multichannel analog systems. Because it is possible to send a 0 dBm0 test tone, one at a time, over every channel,

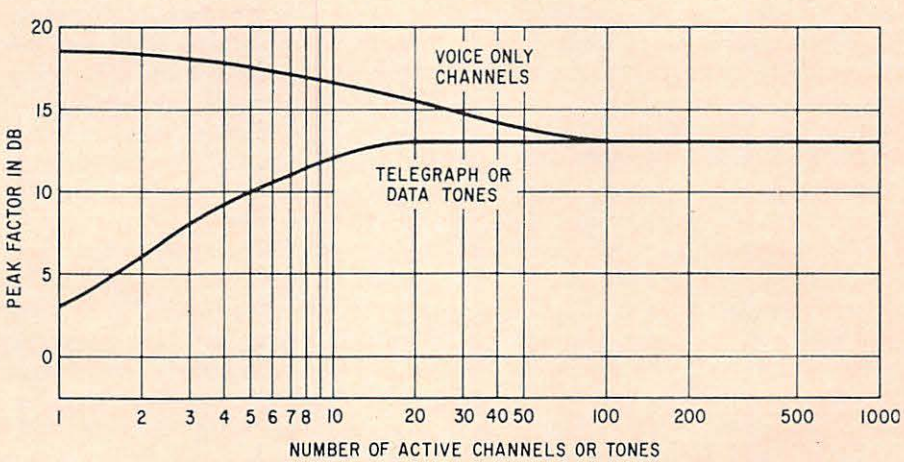


Figure 1: Multi-channel peak factor.

TABLE A

COMMONLY USED LEVELS FOR
DATA APPLIED TO A VOICE CHANNEL

	CCITT	U.S.
High speed data	-10 dBm0 simplex -13 dBm0 duplex	-10 dBm0 switched - 8 dBm0 private line (- 5 dBm0 occasionally)
Medium speed data		-8 dBm0 total power
Telegraph speed data		-8 dBm0 total power
12 or less	-19.5 dBm0 each (-8.7 dBm0 total)	
18 or less	-21.25 dBm0 each (-8.7 dBm0 total)	
24 or less	-22.5 dBm0 each (-8.7 dBm0 total)	
Phototelegraph (fax)	-10 dBm0 for FM 0 dBm0 absolute power for DSB-AM	-8 dBm0

there is a tendency to think of the allowable channel load as being something in this neighborhood. But this is wrong. The allowable average channel load is much closer to the −15 dBm figure.

In fact, if we establish the criterion that the power sum of all of the data tones applied in a single voice channel shall not exceed −15 dBm0 RMS, we can indiscriminately mix voice and data on the channels without any limitations. We can even load up all channels with data without exceeding any of the loading limitations, either of the carrier equipment or the microwave equipment—assuming that they were designed to satisfactorily handle the load of all channels when loaded with voice.

There is only one little hitch with the above method. The data people generally are not quite satisfied with these levels but want higher levels in order to improve their signal to noise ratios and reduce their error rates. This complicates the picture, since a channel with data will now contribute more loading than the same channel with voice. This is the factor which has led to so many contortions with respect to system loading for data.

Some patterns have already become fairly well established in the telephone industry for data levels (and in some cases adapted by utilities), and it will be useful at this point to look at a few of them.

As is evident, all of these levels result in per channel average powers in excess of the −15 dBm0 average for voice channels. (The CCITT values for telegraph type channels add up to a total RMS power of −8.7 dBm0 in each of the three categories).

The −5 dBm0 levels occasionally used obviously provide extremely equivalent loading, since one data channel contributes as much power as 10 voice channels. Even at −8 dBm0 a data channel would equate to the power of 5 voice channels.

It is fairly obvious that when data or telegraph is operated over any sizeable percentage of the voice channels, at levels such as those discussed above, something is going to have to give. There are several possibilities. One is a "brute force" method, to remove for every data channel, the number of telephone channels whose total RMS load corresponds to that of the data channel. For example, adding one −5 dBm0 data channel would require removing ten telephone channels. This method will work, but it eats up channel capacity so fast that it becomes self-defeating. Thirty such data channels, for example, would use up the entire capacity of a 300 channel system. Another possibility is to sharply limit the percentage of channels which can be used for data, and distribute them throughout the system in such a way as to ensure that no item of common equipment will have any serious overloading. This is a method which is widely used.

A third possibility is to design equipment to carry the higher loadings associated with data transmission. Considerable progress has been made in this direction. A fourth possibility is to drop the data levels down a bit nearer to the equivalent voice channel load, and juggle the totals around in such a way as to provide a compromise solution which provides an acceptable level of performance for the operation desired.

The above discussion has centered around data circuits operating over voice channels. For wideband data, for example 40.8 kilobit data operating in a 48 KHz basegroup, or for even higher speed data in a supergroup, the pattern has been to apply the data to the system at a power level about equivalent to or somewhat lower than that of the displaced voice channels. In some cases coding or other sophisticated techniques may be used to reduce the loading effect of the data on the system.

Effect of high level tones: We have so far discussed the effect of data in terms of its contribution to the total RMS loading, without considering anything other than the summed RMS power of all the tones. This is a satisfactory procedure insofar as loading is concerned. However, if a considerable amount of this power is concentrated in one or two steady high level tones rather than a number of lower level tones, some other undesirable results may occur. Discrete intermodulation products of considerable magnitude may be created, instead of a random "babble" of widely spread smaller products. Even worse, the tones may interact with some speech components to produce intelligible crosstalk in some channels, a highly unsatisfactory situation. In the case of wideband transmissions requiring relatively high level tones the effect is sometimes alleviated by the use of a "scrambler" which causes data transitions to be transmitted even when no change is occuring in the input. As long as data transitions are going on, much of the energy in the carrier is split up into the sidebands, and the effect is essentially eliminated.

Let's assume we are talking about a typical situation in private line communication systems, a 6 GHz microwave system channelized with a standard configuration of SSBSC multiplex.

Channel bandwidth and frequency response are almost entirely a function of the multiplex equipment. The standard voice channel characteristics are usually satisfactory for most data applications. High speed data, such as 2400 bits per second, may require some additional equalization which is easily applied at the end points in cases where a dedicated, full period channel is used for the data. Fax (facsimile) requires careful equalization.

Level stability is entirely adequate for most data systems. Amplitude modulated data transmissions, such as facsimile, are sensitive to amplitude changes, particularly if they are sudden ones.

Channel frequency stability is entirely a function of the multiplex equipment, since the FM radio introduces no frequency change. Multiplex systems of good modern design typically will maintain the channels within about 1 or 2 cycles without synchronization. However, many users with heavy data requirements prefer to have their systems fully synchronized.

System design requirements with respect to white noise ordinarily are not changed by the addition of data. However, for systems which are to have very heavy data loading, one might well consider designing the microwave paths for somewhat higher RF signal levels. This might, if it proves necessary, allow some reduction in baseband transmission levels to provide a better balance between thermal and intermodulation noise at the increased loading.

The reduction of impulse and transient noise is of very great importance in systems carrying data, the more so since it is ordinarily unnoticed in systems carrying voice only. Fortunately microwave transmission is not troubled by static or man-made interference of the impulse type. But the designers of the microwave and multiplex equipment must take positive measures to eliminate the generation of transients in the equipment itself. Relays and switches are prolific sources of transients, and if used it is essential that suitable suppression methods be applied. Adequate filtering must be provided to prevent transients from getting into the equipment through the power mains. Power supplies themselves must be thoroughly filtered. Receiver combiner or transfer circuits should be of the high-speed, hitless type, as also the transmitter transfer circuitry in hot standby arrangements. And of course it is necessary to provide extremely good shielding and grounding of the equipment and the wiring.

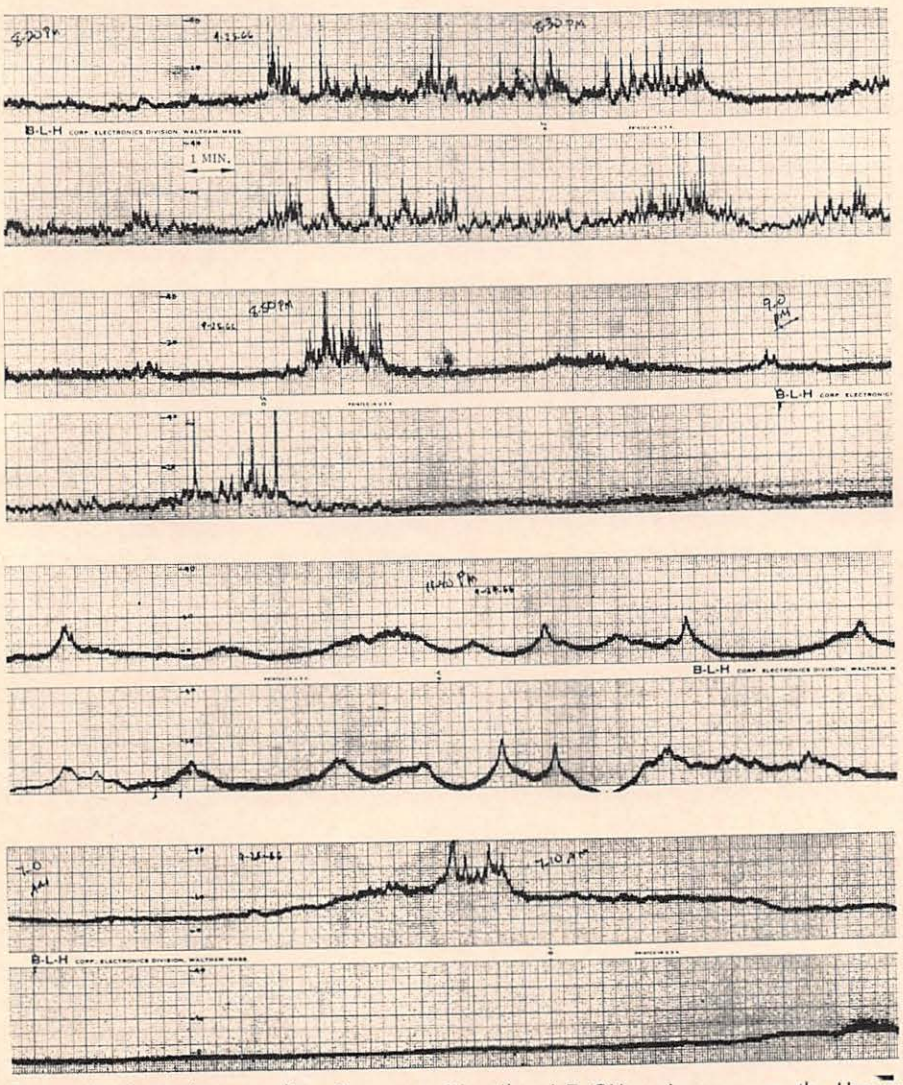


Figure 2: Vertical space diversity on a 26 mile, 6.7 GHz microwave path. Upper antenna at 110 ft, lower antenna at 50 ft. Traces record AGC voltages.

It is of equal, if not greater importance, to prevent transients generated outside the transmission equipment from getting into the circuits. Telephone switching equipment, for example, may generate many high level transients which can easily get into the system either directly or by coupling from cable pair to cable pair, external to the communications equipment. Battery chargers, and other electronic equipments of many kinds can be sources of very high level transients which by one coupling means or another can often get into the communications lines.

Some of the measures which may need to be taken to clean up transients from outside are physical separation of the communications equipment from the transient generating items, use of shielded pairs for external connections, and thorough attention to grounding and bonding of the various equipments.

One very obvious environment which may require careful attention is that which is likely to prevail in a communications station located in high voltage electrical power station or sub-station. Here the air, and the very ground itself may be blue with transients, and getting a clean ground for the communications system may be a difficult problem indeed.

I don't want to give the impression that the impulse noise problem is insoluble. It is not. But it does require attention to details that previously were not of great importance.

Delay distortion, another parameter of significance to data but not to voice, is — in systems of this kind — almost entirely a function of the carrier euipment. Even more specifically, of the filters in the carrier equipment. Frequencies near the edge of the filter band tend to travel at slightly different velocities than those near the band center. It is possible to equalize out these delay differences to almost any extent desired, but in general it is not economic to equalize all channels of a system. The usual practice now is, for data systems which require it, to provide equalizers associated with the data equipment. For full period, permanent circuits these equalizers can be adjusted to match directly the characteristics of the voice channel. For systems operating over a switched network it is not quite so easy, since different channels may have somewhat different characteristics. In such cases a compromise equalization setting may be used.

For sub-multiplexed telegraph speed data circuits, which use only a portion of the voice channel, the delay distortion requirements are less stringent and are usually satisfactory without equalization, unless it is necessary to get the maximum possible number of sub-carriers into a single channel.

Short period outages and diversity: Earlier I mentioned the fact that high speed data, and to a lesser degree even low speed data, is considerably more likely than voice transmission to be seriously affected by the very short, deep fades associated with multipath fading. The effects of this kind of fading can be greatly reduced — we might almost say completely eliminated — by suitable diversity. In private systems in the 6 GHz band this must be height diversity (vertical space diversity) because FCC will not license frequency diversity. (An alternative is cross-band diversity, with one frequency in the 6 GHz band and the other at 12 GHz).

We have installed a fairly large number of height diversity 6 GHz paths, and have found the propagation protection against multipath fading to be exceptionally good, using spacings on the order of 30 ft to 40 ft between the upper and lower antennas. Figure 2 shows simultaneous recordings of the signal levels on the upper and lower paths of a space diversity hop. It can be seen that although each path separately experiences many very deep fades, they are never coincident on the two paths. Thus, one can see how the combined output signal completely eliminates the effects of the multipath fading (see page 25).

A point of considerable interest on these slides is the very short time of the deep fades. In almost all cases the down and up lines on the deep portion of the fades are coincident, and the chart speed is such that such a fade must be about a second or less in duration. When a path is in a heavy fading condition, there may be a half dozen or so of these deep, sharp fades within a few minutes, each great enough to cause a mute even on a path with a 40 dB fade margin.

Because the fades are so very short, the percentage of time either path alone is below threshold is very small, even with the heavy fading shown. But even a very short "outage" percentage can be very troublesome to data if it is made up of a large number of separate hits. Suitable diversity can reduce the number as well as the total time of such multipath hits by factors of 100 to 1 or even more, thus essentially eliminating the problem. Whether or not the slightly greater cost for a diversity system is justified must be determined by the user on the basis of what his requirements are. For some systems it will not be necessary, but for highest reliability, the diversity is an extremely valuable tool to have available.

TABLE B

A	B	A	B	A	B	A	B
0.0	3.010	3.0	1.764	6.0	0.973	19.0	0.054
0.2	2.911	3.2	1.698	6.5	0.877	20.0	0.043
0.4	2.815	3.4	1.635	7.0	0.790		
0.6	2.721	3.6	1.573	7.5	0.710		
0.8	2.629	3.8	1.513	8.0	0.639		
				8.5	0.574		
1.0	2.539	4.0	1.455	9.0	0.515	25.0	0.016
1.2	2.451	4.2	1.399	9.5	0.461		
1.4	2.366	4.4	1.345	10.0	0.414		
1.6	2.284	4.6	1.293	11.0	0.331		
1.8	2.203	4.8	1.242	12.0	0.266		
				13.0	0.216	30.0	0.004
2.0	2.124	5.0	1.193	14.0	0.170		
2.2	2.048	5.2	1.146	15.0	0.135		
2.4	1.974	5.4	1.100	16.0	0.108		
2.6	1.902	5.6	1.056	17.0	0.086		
2.8	1.832	5.8	1.014	18.0	0.068		

This table may be used to sum the power of two unequal, non-coherent signals expressed in dB. Column A lists the difference in dB between the two signals; the figure taken from Column B is to be added to the larger of the two signals to get the summed power. The process can be iterated to sum a third power to the other two, and so on.

The B figures are given to 3 decimal places to avoid round off errors in iteration, but final figures should be rounded off to agreee with the accuracy of the basic data.

The table may be used to sum powers with negative as well as positive coefficients provided proper attention is given to signs and it is remembered that with negative coefficients a higher numberical value represents a lower power.

Example: To add, on a power basis, a power of -4.2 dBm and a power of +2.1 dBm.
The difference is 2.1 - (-4.2) = 6.3 dBm.
By visual interpolation, this corresponds to a B value of 0.9, to the nearest tenth.
The summed power is then +2.1 dBm + 0.9 = +3.0 dBm.

Loading and design: In the earlier discussions on loading it was pointed out that the addition of data to a voice designed system posed no problems as long as the power of the tones used to transmit the data in a single voice channel were kept down to about the -15 dBm0 equivalent power of the voice transmission which they replaced. The problem comes because it is usually desired to transmit data at higher levels.

Let's make some practical assumptions, based on the practices which have been developed in the telephone industry. One would be to assume that for a channel devoted telegraph type subcarriers, the total RMS power of the tones would be held at no more than -8 dBm0. For data occupying a full channel, the power would be normally -8 dBm0, or in rare cases, -5 dBm0.

Let's consider the effect of such heavy loading in relation to equipment design. I'd like to take as an example the design parameters chosen for the Lenkurt 46A multiplex system, and compare them with CCITT loadings. The design is based on a mixed loading in which 75% of the channels are used for voice transmission, 17% for telegraph or for −8 dBm0 data, and the other 8% for −5 dBm0 data. For a 600 channel system this would be 450 channels of voice, 102 channels at −8 dBm0 data, and 48 channels of −5 dBm0 data.

The equivalent RMS white noise load for 450 voice channels at an average of −15 dBm0 would be +11.5 dBm0, the equivalent load of the 102 data channels at −8 dBm0 would be +12.1 dBm0, (−8 +10 log 102) and the equivalent load of the 48 data channels at −5 dBm0 (−5 +10 log 48) would be +11.8 dBm0. Summing these three loads on a power basis, using Table B gives a total equivalent white noise load of +16.6 dBm0, nearly 4 dB higher than the +12.8 dBm0 CCITT equivalent load of 600 voice channels.

At channel level there is no loading problem. A channel designed to handle the high peak load and the "bull talker" is more than adequate to handle the peaks of data even at the −5 dBm0 level.

At group level the CCITT equivalent load for 12 voice channels is +3.32 dBm0, based on the −1 +4 log N formula. The equivalent load of 12 channels loaded with −8 dBm0 data would be +2.8 dBm0, about a half dB *less* than the CCITT load, while the equivalent of 12 channels loaded with -5 dBm0 data would be +5.8 dBm0, or some 2.5 dB higher than the CCITT load at this point. For intermixtures of voice and data the statistics get somewhat uncertain, because of the small numbers of channels, but taking worst case assumptions one can calculate a maximum equivalent load for any combination of 12 channels carrying either voice or −8 dBm0 data as +4.2 dBm0, and a maximum equivalent load for any combination of 12 channels carrying either voice or −5 dBm0 data as +6.3 dBm0.

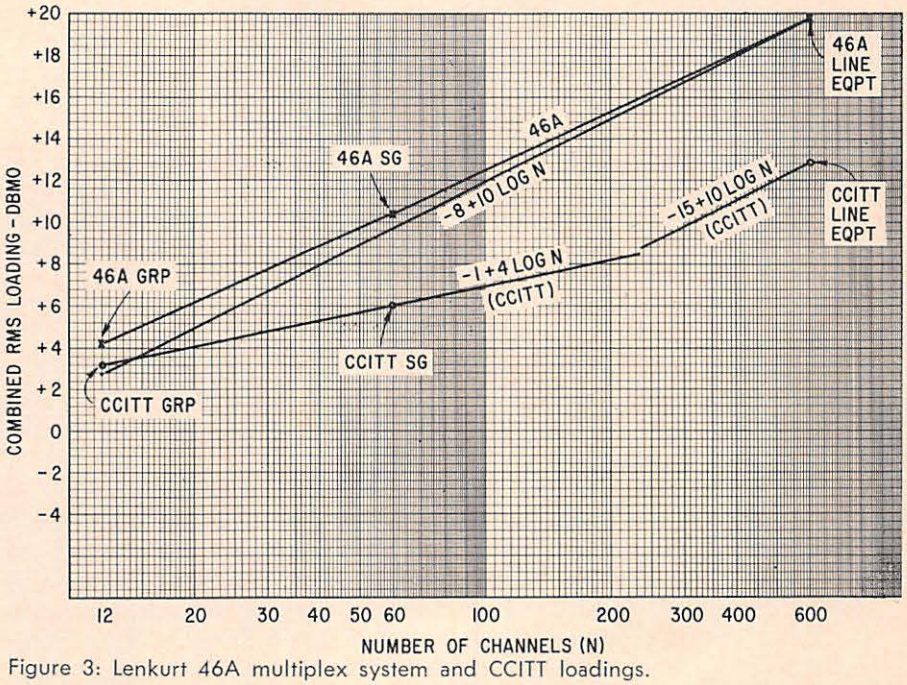


Figure 3: Lenkurt 46A multiplex system and CCITT loadings.

At supergroup level the CCITT equivalent load for 60 voice channels is +6.12 dBm0, based on −1 +4 log N. If all 60 channels are loaded with −8 dBm0 data, the equivalent load would be +9.8 dBm0, and if all channels were loaded with −5 dBm0 data the equivalent load would be +12.8 dBm0. The maximum equivalent load for any mixture of voice or data at supergroup level is very close to the load when all 60 channels are occupied by data.

At line levels the CCITT equivalent load for 600 voice channels is +12.8 dBm0, based on −15 +10 log N If all 600 channels are loaded with −8 dBm0 data, the equivalent load would be 7 dB higher than CCITT, i.e., at +19.8 dBm0. For all 600 channels loaded with −5 dBm0 data the equivalent load would be +22.8 dBm0, 10 dB higher than CCITT loading. At line levels, any combination of voice and data gives lower loading than when all channels are loaded with data.

The design of the 46A equipment, as shown in Figure 3, is to handle equivalent loads of +4.2 dBm0 at the group level, +10.4 dBm0 at the supergroup level, and +19.8 dBm0 at the line level. The values are respectively, approximately 1, 4, and 7 dB higher than the corresponding CCITT loadings. These loading capabilities allow the use of any mixture whatever of voice and −8 dBm0 data, even up to loading every channel of the system with data. It does *not* allow indiscriminate use of data at −5 dBm0, but does allow the use of up to 48 channels of such data, with the single restriction that no more than two such channels are to be used in any one basegroup. Note that the other ten channels in the basegroup can still be used for voice.

So far I have discussed the effects of loading only in connection with the multiplex equipment. It is equally important, of course, to consider its effects in the transmission medium, in this case the microwave system. The problems in the two portions are somewhat different. Each area is important, but in some ways the problem is more complicated in the multiplex; this is the point in the system at which the relationships between data levels

and voice levels are established, and the whole conglomeration of channels brought together into its final form. It is of great value to a user if he can be freed to as great an extent possible from artificial restrictions on which carrier channels can be used for data, and which for voice.

Consider the question of the heavier loading on the microwave portion of the system. The CCITT and CCIR equivalent white noise load for a 600 channel system would, as we have indicated earlier, be +12. 8 dBm0, based on −15 + 10 log N. In the earlier discussion I mentioned that the 46A multiplex, at the line level, was designed to carry 600 channels at an equivalent loading of +19.8 dBm0, 7 dB higher than the CCITT loading. What about the ability of a microwave system to carry such a higher loading?

The channel noise performance of a given microwave system is a function of a fairly intricate balancing of a number of things, including system bandwidth, per channel deviation, RF signal level, and others. For a given system bandwidth, loading, and RF signal level one could determine, by calculation and testing, a per channel deviation which would provide the best balance between thermal noise and intermodulation noise in the worst channel. But if the loading is increased, a different optimum deviation would apply unless some of the other factors are also changed.

A given microwave system will have a peak deviation capability which corresponds to some extent to the breakpoint of an amplifier, except that it is a much "softer" type of limitation, and the penalty for exceeding it is not so severe. Let's talk about some specific parameters, again in terms of a system designed to handle 600 channels based on CCIR recommendations. The design load, as indicated earlier, would be an equivalent white noise of +12.8 dBm0. The per channel deviation, for a 0 dBm0 test tone, would be, per CCIR standards, ±200 KHz RMS. When we load the system with white noise at a level if +12.8 dBm0, the RMS deviation of the complex signal will be 12.8 dB above ±200 KHz, and the peak deviation – taking into account the 13 dB peak factor – will be 13 dB above that. Thus the peak deviation will be 25.8 dB above ±200 KHz, or ±200 KHz times the antilog of 25.8 over 20. This gives the peak deviation as ±3. 9 MHz.

Now let's see what happens to the deviation if we increase the load to +19.8 dBm0, 7 dB higher. The peak deviation will then become ±3.9 MHz times the antilog of 7 over 20, which works out to about ±8.7 MHz. This would require a much greater bandwidth and would also impose much more stringent requirements on the equipment design.

The +19.8 dBm0 figure used in the above example is really not a very likely one, since it was arrived at by assuming that *all* channels of a 600 channel system are occupied by data at −8 dBm0. A much more realistic assumption – in most cases – would be to assume that no more than 25% of the channels were occupied by data at this level and the rest by voice. This gives a loading of +15.8 dBm0, which is only 3 dB above the normal loading level and is a much more manageable figure.

If the system is conservatively designed, and if the signal to noise ratios under normal loading are quite good, it is possible that the increase in intermodulation noise because of the heavier loading would be small enough to be acceptable.

Another approach would be to reduce the channel deviation slightly in order to approach a new optimum point. Reducing the deviation would improve the signal to intermodulation noise ratio, but would degrade the signal to thermal noise ratio. If this approach is used, we may also consider increasing the RF signal level, which will reduce the thermal noise. Assuming that adequate baseband gain is available at the receive end, a very simple way of reducing the effective deviation by 1 dB is to insert a 1 dB pad between carrier and microwave at the transmit end, and remove 1 dB of pad between the microwave and the carrier at the receive end. Such an expedient would have the effect of dropping the deviation, but would allow standard test tone levels and instruction book material to be used in alignment and maintenance of equipment. There are of course other equivalent ways of accomplishing the same thing.

There is another aspect of this matter which applies particularly to industrial users in the 6 GHz band. As is well-known, FCC puts a limitation on the allowable emission, and this in turn puts a limit on the allowable peak deviation. The 10000-F9 emission designator limits the "necessary bandwidth" to 10 MHz or less. The necessary bandwidth is defined as equal to 2M + 2DK where M is the top modulating frequency, D is the peak deviation, and K is a constant which is usually taken as either 1 or .9 in this application.

Using standard CCIR deviations and loadings, one can use up to about 420 channels in the 6 GHz band and still stay within the 10000-F9 limitation. More channels can be used if deviation is lowered; this of course causes an increase in the channel noise.

If we work backwards from the 2M + 2DK formula to find the allowable deviation for a 300 channel system we can arrive at an interesting and useful conclusion. The top channel of a 300 channel system falls at about 1.3 MHz. Using that value M, a value of 0.9 for K, and 10 MHz for the "necessary bandwidth", we have

10 MHz = 2 x 1.3 MHz + 2D x 0.9

which reduces to D = 4.1 MHz

This is slightly greater than the deviation corresponding to a 600 channel system. Since the equivalent loading for a 600 channel system is 3 dB greater than the equivalent loading for a 300 channel system it is evident that we can operate a 300 channel system at 3 dB higher than normal loading without exceeding the bandwidth limitation imposed by FCC.

Earlier in the discussion it was pointed out that for a mixture of 25% data at −8 dBm0 and 75% voice, the load of a 600 channel system would be just 3 dB greater than that for 100% voice. The same figures may be applied to a 300 channel system.

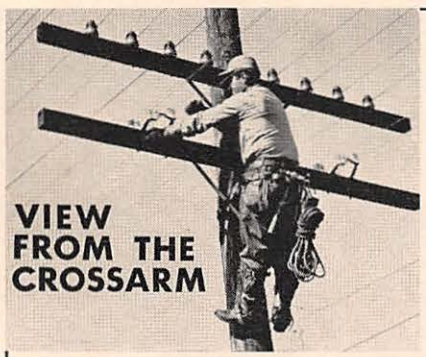
So here's one possible solution to the heavy loading problem. Use a microwave system which is basically capable of 600 channel operation, and design the system so as to give satisfactory performance if it were used for 600 channels voice. Then it can be used for 300 channel operation with up to 75 of the channels used for −8 dBm0 data. FCC limita-

tions will be met, and channel performance should be equal to that of a 600 channel normally loaded system.

The private system user has some other, and perhaps better, possibilities at his disposal. The common carrier communications companies, who are concerned with operating data over switched networks, and for a great variety of users, must of necessity provide a large measure of standardization of levels, loadings, etc. Furthermore, their systems must operate over as many as nine randomly switched tandem connections. The private user on the other hand has a much greater degree of control over his system. Furthermore, he is in a position to evaluate his own needs and to make decisions which the common carrier could not. For example, a private user may well be willing to accept a slightly higher noise level in his voice channels in order to get more data on his system. Or, if voice quality is the primary concern and the data is secondary, he may drop the data levels to the point where they don't affect the voice channels. He is also in a much better position to determine by actual testing the optimum level for data, or at least to determine levels which will provide satisfactory data operation without unduly affecting the voice operation. In the final analysis, the best test is actual operation on the system.

The data levels (around −8 dBm0) discussed earlier are really based on random selection of telephone facilities in tandem, as encountered in common carrier networks. Private systems which are well designed and in which impulse noise is controlled can operate data circuits at considerably lower levels, particularly if diversity is used on all paths subject to deep fades.

Here is a point which can be of considerable significance. As was mentioned earlier, there will be no increase at all in system loading if data tones are inserted at such a level that the sum of the RMS power of the tones in any voice channel does not exceed −15 dBm0. The reason for operating data at a higher level is primarily to ensure that the data channel signal to noise ratio will still be adequate when the system is at the maximum allowable noise level. In a system operating over microwave this maximum noise usually occurs only when one of the paths is in a deep fade. When adequate diversity is used on each path, not only will there be near perfect protection against simultaneous very deep fades, but there will also be a large measure of protection against even fairly small fades. During fading periods there is a strong tendency toward negative correlation of the fading on the upper and the lower antennas. Thus, on a system fully protected by diversity, it might very well be possible to drop the level of data by several dB below those discussed earlier. This would bring the loading back nearer to that of voice alone and allow even more channels to be used for data. **RS&C**



• **Engineer's Relay Handbook** provides engineers, management, and technicians with a source of information on operating principles, properties, performance characteristics, application requirements, specifications, and testing of relays.

Information contained in the book is aimed at those individuals responsible for specifying the correct type of relays for a given application. It appears that the editors have made a special effort to cover specification parameters in detail.

It is pointed out that actually it is not difficult to prepare relay specifications if the specification writer is aware of all the application requirements of the particular relay. The smallest detail may be of significance to the supplier.

Two simple rules to follow in writing a good relay specification are outlined: (1) Include all functional requirements of the relay. (2) Exclude all perfunctory and superfluous items. These simple points constitute the basic theme of that section of the Handbook on How to Specify a Relay.

The authors have gone to some lengths to discuss most of the factors which should be included in a specification and to provide a solid foundation for the prospective user and specifier of relays.

Three sections of interest are: Relay Terminology, Principles of Relay Operation, and Relay Application Considerations.

The section on terminology includes classification, definitions, terminology, and symbols—of relays—for general switching purposes and electronic circuits. The section is well illustrated and easy to understand.

Principles of operation outlines the fundamental operating principles of light-duty electromagnetic relays.

Relay performance, the authors explain, "follows precise rules of physics, chemistry, and metallurgy. When these rules are observed or violated, the relay behaves accordingly." This section deals with those principles of particular concern to circuit designers.

That portion of the book devoted to application, comprehensive in coverage, should provide an authoritative reference for the relay user.

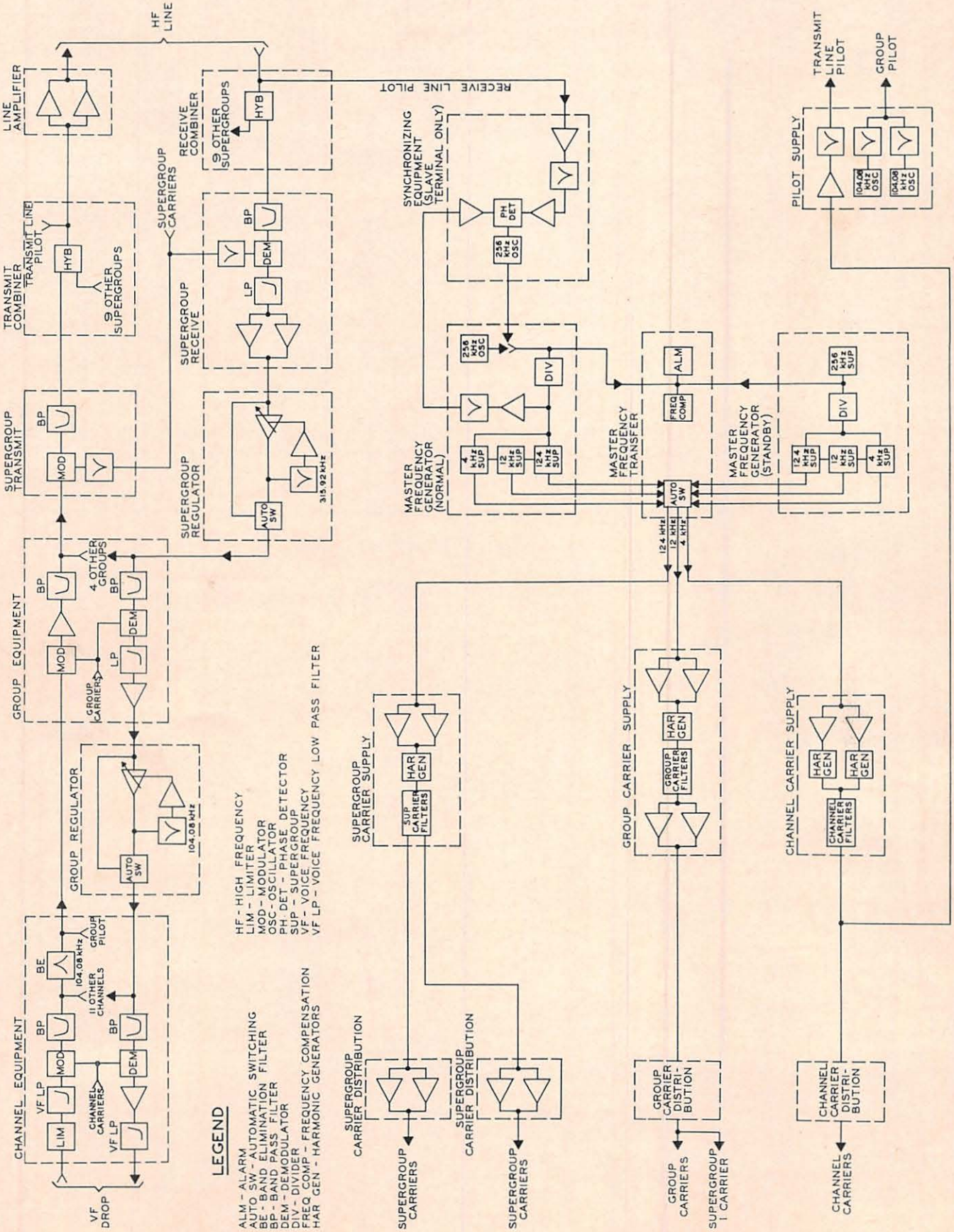
Engineers and signalmen alike should find "Design analysis" interesting, as a number of critical design factors are briefly and concisely outlined.

The Handbook is available from Hayden Book Co., Inc., 116 West 14th St., N.Y., N.Y. 10011. Cost—$11.95

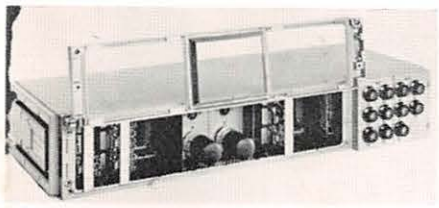
View from the Crossarm is generally devoted to subjects related to education and training in the field of signaling and communications. If you have information of interest or ideas which will be useful to the readers of this column send them to the Crossarm Editor, RS&C, 14 E. Jackson Blvd., Chicago, Ill. 60604.

Multiplex-46A 600-CHANNEL SYSTEM

Prepared by Thomas Curry
LENKURT ELECTRIC CO., INC.



PRODUCT NEWS



Electronic Track Relay

An electronic track relay has been developed for use on European railways. It is not available to U.S. customers.

Designed on the fail-safe principle the electronic track relay group works on the controlled rectifier principle. It incorporates an amplifier tube which is controlled by the track current. Phase reversal to differentiate between signal and interference voltage is effected by means of a counter winding.

The equipment, made up of standardized telecommunications components, is designed for use on both electrified and non-electrified lines.

Track circuit power requirements are reduced to a minimum when this electronic equipment is used since only the amplifier tube is controlled by the track circuit while the power for relay energization is obtained from the main supply. The tube is controlled by DC and it, in turn, controls two DC relays which indicate the clear and occupied conditions of the track.

Source current is supplied to the rails through a track feed transformer. Surge protection is added by connecting an arrestor in parallel with the transformer. A limiting resistor is included to hold the current at admissible values when the track is occupied. The track relay transformer is connected at the other end of the track section. The desired track voltage, obtained at the secondary is applied to the electronic relay group. Any phase displacement can be corrected by trimming capacitors.

In electrified territory impedance bonds are used and surge arrestors are provided for the track relay transformer as well as for the track feed transformers. *ITT Corporation—Standard Elektrik Lorenz AG. Circle 1 on Reader Service Card.*

• FAULT LOCATORS: A new 12-page Bulletin 65 illustrates and describes cable fault locating equipment. It provides information on tracer types and describes the theory of operation, advantages of the impulse method, and offers a discussion of impulse generators. The high voltage bridge, standing-wave generator, wheatstone bridge and bridge megger are also included. It is pointed out that it is sometimes necessary to reduce fault resistance to successfully utilize various types of fault-locating equipment, therefore, items of "burndown" equipment are included. *James G. Biddle Co. Circle 2 on Reader Service Card.*

Microwave Terminal

A new, battery-saving, shallow-rack 960-channel microwave terminal and remodulating repeater uses 33% less power, occupies less floor space, and is engineered for long-haul, high-quality, frequency diversity transmission in the 5925 to 8400 MHz. band.

Swing-out front doors make all waveguide components and circuits readily accessible from the front and eliminate the need for technicians to go behind racks for operational checks or maintenance. This permits two racks to be placed back-to-back, side-by-side, or flush to the wall.

The system is available for DC battery operation or AC. Transmitter output is one watt and battery drain for a basic terminal is 260 watts.

Silicon transistors and a vapor-cooled transmitter klystron are used.

Railway Signaling & Communications

14 E. Jackson Blvd., Chicago, Ill. 60604

Attn: R. W. McKnight

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PRODUCT NEWS

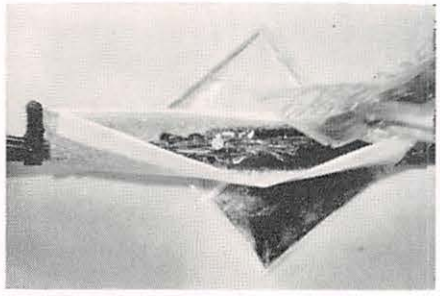
Other circuits are solid state.

The solid-state receiver is a single heterodyne design with both automatic frequency control and automatic gain control.

The equipment power supply, mounted at the bottom of the rack, provides all the voltages necessary to operate one transmitter, one receiver and auxiliary equipment. This unit has been designed for efficient use of unregulated 48 VDC input ± 18%. *General Electric. Circle 3 on Reader Service Card.*

• TERMINALS AND CONNECTORS: Power terminals, high voltage connectors, straight and T-connectors, reducing adaptors and specialty products for wires ranging from No. 6 to 2,000 MCM are shown in a new catalog. They are illustrated and charted for cable size, and mounting screw size in addition to hole, indent, and other dimensions pertaining to their varied applications.

Also included are compression tool references for use with the line. *Crescon Accessories Div. of Crescent Insulated Wire and Cable Co. Circle 4 on Reader Service Card.*

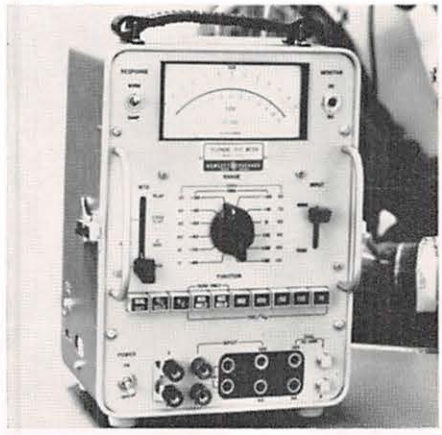


Splicing Kit

A new direct burial splicing kit encapsulates and insulates splices in a moisture seal of epoxy resin. The mold is made from an electrically pure webbing on a polyester film. Putty sealing strips complete the mold into which Scotchcast resin is poured. The resin, mixed in its unipak container, ensures proper mixing ratios and eliminates air and humidity contamination. *3M Co., Dept. of Communications. Circle 5 on Reader Service Card.*

• CAR RETARDER: Operation and application of weight-compensating car retarders with electronic speed control is described in a new brochure. The retarder provides a braking force in direct proportion to the weight of each individual car. Braking force is released by electronic speed control so that cars exit from the retarder at a pre-set speed. Both individual cars and large cuts can be retarded to any desired speed. *Abex Corp. Circle 6 on Reader Service Card.*

• ANTENNA SYSTEMS: Detailed product information and engineering data on microwave, UHF, VHF, telemetry antennas, flexible coaxial cables and elliptical waveguides, switching and pressurization equipment and system accessories such as radomes, positioners and telescoping masts is contained in a new 128 page catalog. *Andrew Corp. Circle 7 on Reader Service Card.*



Test Equipment

A new, lightweight telephone transmission measuring set will bridge or terminate transmission lines of any standard impedances. It will measure transmission frequencies from 30 Hz to 3 MHz, eliminating input repeat coils, by substituting a fully-protected differential amplifier.

The unit makes universal line level measurements and performs noise measurements. Both noise-to-ground and noise-metallic measurements can be made, enabling easy and rapid calculation of line balance. Sensitivity of the meter is sufficient

(Please turn to page 35)

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Another part of the plate adds power, too. It's the row of specially braided fiberglass sleeves that fit over those core rods. They hold the active material—actually press it closer to the grid to make the charge last longer.

To learn more, write: Industrial Group, ESB Incorporated, Box 5723, Philadelphia, Pa. 19120.

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KINKS

AFO and OTC Tests

J. L. McNabb
Chicago, Ill.

Manufacturers' test circuits have been incorporated in one unit for testing AFO and OTC equipment. The test box, designed for use by division personnel, included only circuits required to perform basic tests. Major tests and repairs, requiring more sophisticated equipment, are handled by the system repair shop.

The circuits shown are those designed by the manufacturers for testing US&S track and line AFO and GRS OTC equipment. The railroad using this test unit has many installations where audio equipment is used and since it would be inconvenient to maintain separate bread boards for each recommended test, it was decided to design one device to handle all circuit requirements for recommended tests.

All tests, except the diode test circuit, require a 14 to 16 volt power supply. The diode test circuit uses a 40 volt DC supply.

Terminals for load resistors, controlled operating voltage for US&S equipment and battery busses are located at the top of the panel. Lead resistor terminals for GRS equipment are located at the bottom. The circuits for testing various component parts—such as rectifiers, transistors, and diodes—are located in the center area along with a voltage adjusting potentiometer.

A knowledgeable maintainer using any good VOM and an appropriate power supply in conjunction with this test unit, can locate defects and make repairs on most audio track and line circuit equipment simply by following the manufacturers' recommendations.

Floating Charge

J. L. McNabb
Chicago, Ill.

The track rectifier winding of a signal transformer can be used as the AC power supply and the rails as a transmission line for a floating charge on primary battery.

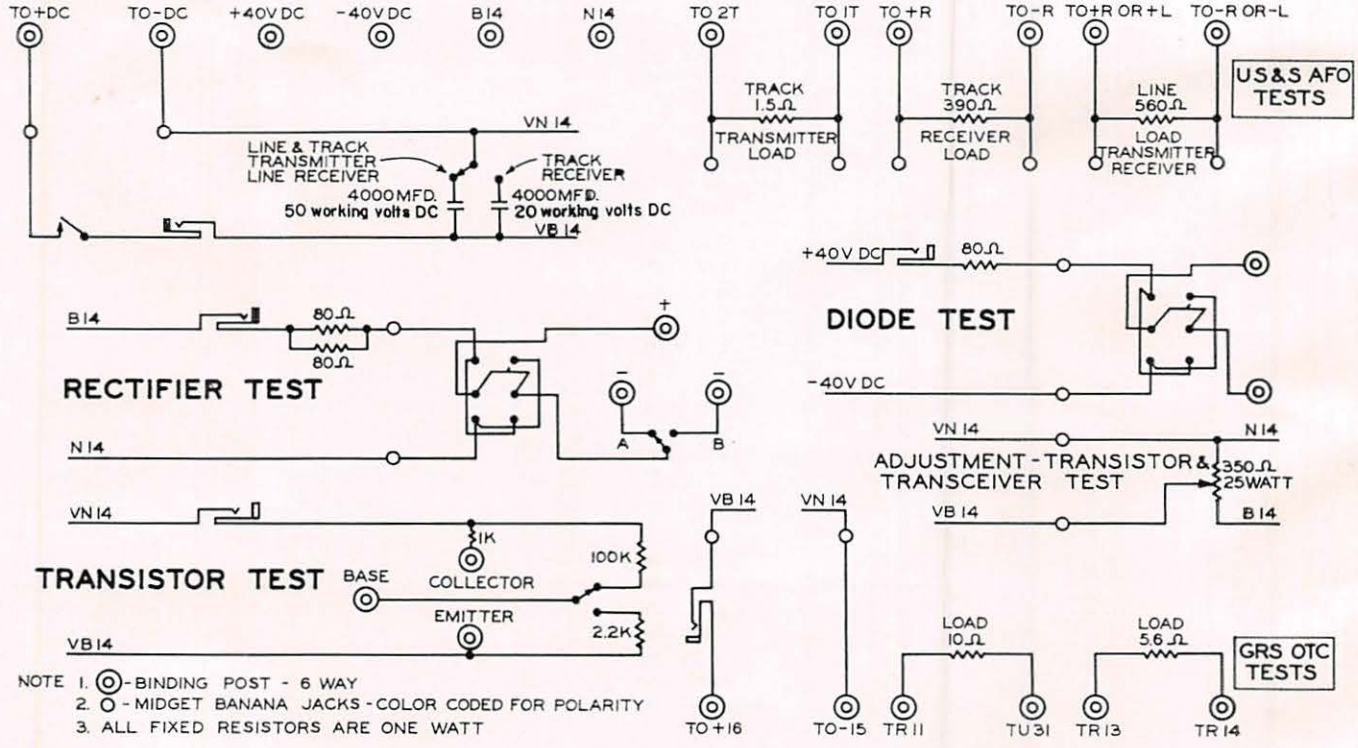
The circuit shown in the accompanying diagram has been successfully used on track circuits at outlying highway crossing signal installations. If the circuit is properly adjusted primary battery life can be extended to 3½ years or more. In addition, track shunting properties when the circuit is used, are far superior to those of conventional track circuits.

The 2000 MFD capacitor is used to block the DC from the secondary winding of the transformer and at the battery end, a rectifier and two resistors are required in addition to the usual equipment. One resistor controls the rectified DC and the other controls the discharge from the primary battery. The circuit should be adjusted for a 10 to 15 ma discharge.

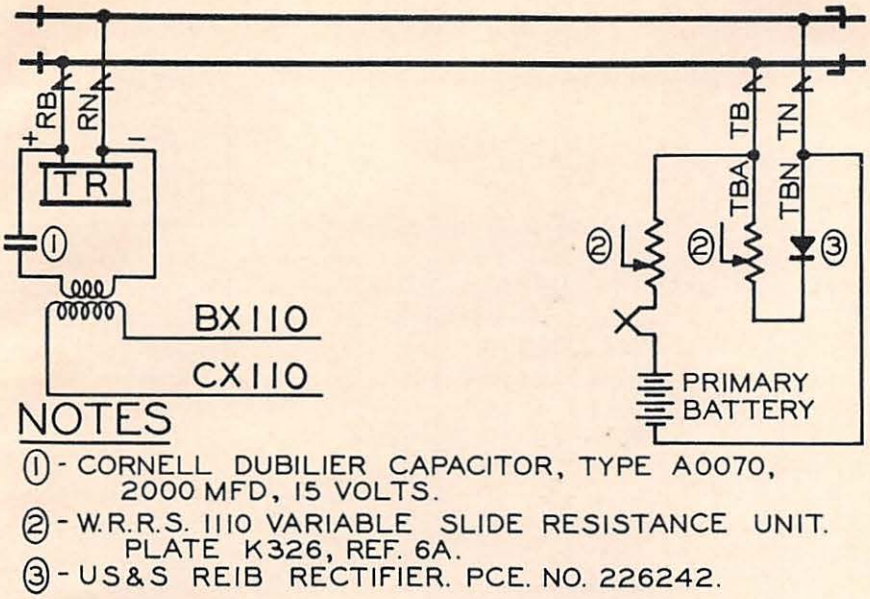
Track arresters should be used at both ends of the circuit to eliminate possible lightning damage to capacitor and rectifier.

This circuit is fail safe. If the capacitor or rectifier is shorted the relay will be shunted and de-energized. At the relay end the RB and RN will be tied together through the secondary winding of the transformer. The rectifier, if shorted, would tie TB to TN through a resistance unit. If either of these units should open, the primary battery would furnish the energy to operate the track relay, avoiding delay due to track circuit failure.

(See next page for diagram)



J. L. McNabb: Test equipment for audio frequency and overlay track circuits.



J. L. McNabb: Track rectifier winding of signal transformer can be used as the AC power supply and the rails as a transmission line for a floating charge on primary battery.

Questions to be Answered in Future Issues

- How do you check point detection on power switch machines?
- Does rainfall affect microwave signals and if so, at what frequencies does attenuation and noise effects become noticeable? At what frequencies are they most pronounced?
- What inspections do you require to be made following severe electrical storms?
- What procedure do you use to prevent corrosion of battery terminals and wire ends on lead acid cells?
- Where diesel-pooling arrangements are in effect between roads, when going from one road to another, how is radio equipment on the trains handled to provide continued use of this equipment for end-to-end and dispatcher-to-train communications? Who makes emergency repairs to radio equipment away from the owning road?
- How do you check insulated joints for current leakage and breakdown of insulation? When rail ends lip over the endpost how is it removed? What equipment is used to remove the rail lip and who performs the work?
- How often is insulation in gauge plates on remotely controlled switches tested and how are these tests performed?
- How do you protect overlay track circuit equipment against lightning strikes and other transients? Do you use zener-diodes as transient suppressors?
- How do you perform the following tests: approach locking, time locking, indication locking, route locking, traffic locking, circuit locking? Who is responsible for the performance of these tests?
- How do you test the conditions of semiconductors in working circuits and out of the working circuits for: forward voltage drop across diode, for excessive leakage current, DC gain of triode or tetrode device, AC gain of triode or tetrode device, characteristics where equipment operates in various local temperature ranges.
- How do you test varactors, silicon controlled rectifier, and tunnel diodes?

Send answers to these questions to the WA editor, Railway Signaling and Communications, 14 E. Jackson Blvd., Chicago, Illinois. 60604. Payment is made for all answers printed. Answers will be printed without names or railroad identification if desired, but all letters with answers must be signed.

PRODUCT NEWS

(*Continued from page 32*)

for measurements to 0 dBrn at 1 KHz.

When measuring transmission a high bridging impedance is provided with flat frequency response over 5 frequency decades. Balanced terminated operation may be selected, at 75, 135, 150, 600, or 900 ohms. The meter reads directly in dBm for the selected input impedance. The instrument retains full performance specs over an operating temperature of 0°F to 120°F. *Hewlett Packard. Circle 8 on Reader Service Card.*

Equipment Enclosure

Constructed of special aluminum alloy, a new concept in equipment enclosures offers resistance to corrosion with a high degree of reflectivity to light and heat. High reflectivity means cooler operation in summer and warmer in the winter.

Each unit is wired with a four circuit fuse panel, ceiling light and environmental control by infra-red lamp and exhaust fan through thermostat control. Units are finished, ready for sitting on the foundation. *Railtron Corp. Circle 9 on Reader Service Card.*

Transistorized Converter

The transistorized B450 "ON" converter that permits application of existing "O" type wire line carrier systems to cable is now available. The B450 translates any "O" compatible or "O" coordinating system (Lynch B510, B500, W.E. "O", or Lenkurt 45C) in frequency for use over an "N Repeatered Line".

Conversion of existing open wire "O" type carrier systems to cable carrier operation extends the life of equipment otherwise nearing technical obsolence. The B450 may be used on an open wire line to cable arrangement or an all cable arrangement.

The system is designed to provide a maximum of twenty ("ON1") or twenty-four ("ON2") channels over a standard "N Repeatered Line" using Lynch B410 "N2" repeaters. The B450 will provide toll quality performance with no alteration of existing "O" equipment required. *Lynch Communication Systems Inc. Circle 10 on Reader Service Card.*

Multiplex-TYPE 46A

Prepared by Thomas Curry
LENKURT ELECTRIC CO., INC.

Of particular interest in the 46A are the two types of combining action used in the operation of redundant circuits. These methods are phase combining and power combining.

With phase combining a signal is separated into two paths, each containing a phase shift network and an amplifier. The separated signals are shifted so that a total phase difference of 120° exists between signals. After being recombined, the resultant signal output is equal to either one of the separate amplifier outputs. As a result, either amplifier may fail or be removed without affecting operation.

With power combining, a signal is separated into two paths in the same manner as phase combining. In each path are squaring amplifiers. The two amplifier outputs are combined in a filter-coupler circuit which is tuned to the signal frequency. The filter-coupler circuit forms a tuned load so that current is drawn equally from each of the amplifiers. If either amplifier fails, the remaining amplifier carries the full load.

The pilots used for regulation also function as overall system alarms. Extreme level changes or loss of pilot activates an alarm at the receiving terminal. Failure of the receive group pilot causes an interruption in the associated transmit group pilot to signal the distant terminal of the abnormal condition. With an automatic reset option, the pilot is restored immediately upon clearance of the trouble.

Loss of the receive group pilot activates either the group pilot alarm or automatic level regulating equipment which, in turn, operates signaling-make-busy (SMB) equipment to prevent users from dialing into a dead circuit. After a delay of 10 to 20 seconds to prevent false operation caused by short duration pilot alarms, the SMB equipment samples the 12 VF circuits associated with the failed group and busies-out any circuits that are not in use. The sampling continues until all the circuits of the group have been busied out. Once the trouble condition has been cleared and the pilot restored, the associated trunk circuits are released and the SMB equipment is automatically disconnected from the circuit.

Group pilots furnished for each group of 12 channels in a system simplifies proper interpretation of the alarms and greatly facilitates locating trouble. For example, a group pilot alarm on one group of a system will indicate trouble in either the transmit or receive group equipment. Five group pilot alarms in the same supergroup will indicate that either the transmit or receive supergroup equipment is faulty. All group pilot alarms at the same time indicate a total failure located in either the transmission facility or in some equipment that affects the entire group and supergroup system.

Group pilots are inserted at a fixed level; hence, they also act as an accurate reference through the transmission system. Since lineup levels are directly related to the group pilot levels, adjustments in the transmit and receive sections can easily be accomplished. For example, when the group pilot level is set at −20 dBm0 (this means that the level is 20 dB below a fixed frequency test tone level), the pilot level at the −15 dBm supergroup transmit point would be read as −35 dBm on a dB meter (−20 dB added to −15 dBm).

Thus, with the Lenkurt 46A maintenance is extremely simple. Further, because of built-in redundancy and standby equipment, systems operate reliably for long periods of time without maintenance.

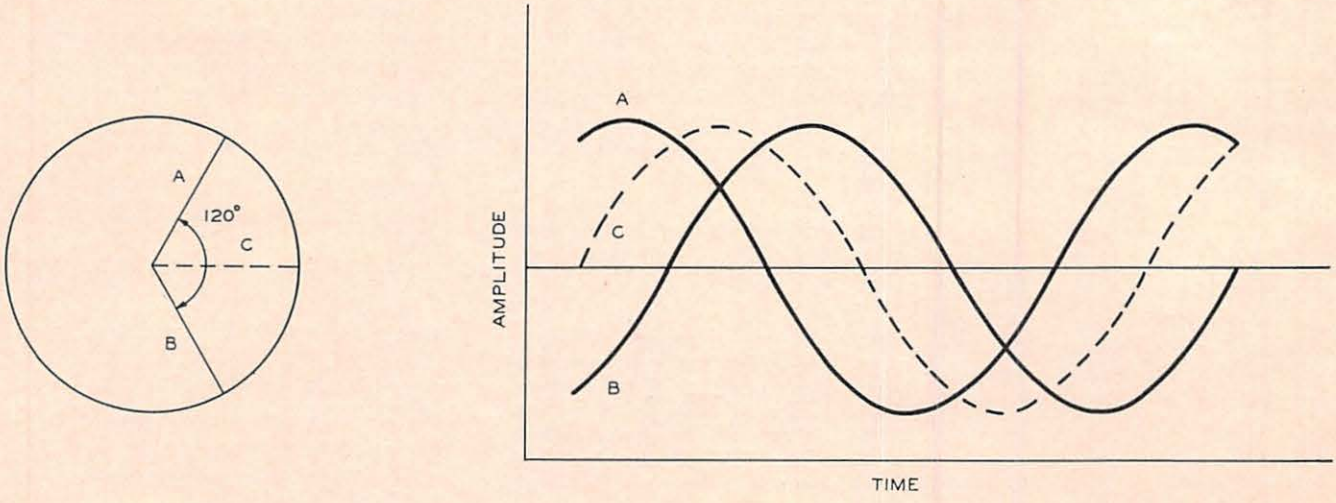


Fig. 20 SIGNAL FOLLOWS TWO PATHS IN PHASE COMBINING

NEWS BRIEFS

(Continued from page 12)

• BROTHERHOOD OF RAILROAD SIGNALMEN delegates in convention August 14-18 elected secretary treasurer **C. J. Chamberlain** to succeed **Jesse Clark,** president, who will retire September 30. **Paul T. Drummond,** vice president, was elected secretary treasurer and **M. B. Frye,** grand lodge representative, was elected vice president—headquarters.

C. K. Fields, vice president—Washington, D.C., will also retire September 30. **B. H. Steuerwald,** vice president—Denver, Colo., will replace Mr. Fields and **R. T. Bates,** Southern Pacific general chairman, was elected to fill the vacancy in Denver. All other officers were re-elected.

Jesse Clark
B of RS

C. J. Chamberlain
B of RS

P. T. Drummond
B of RS

M. B. Frye
B of RS

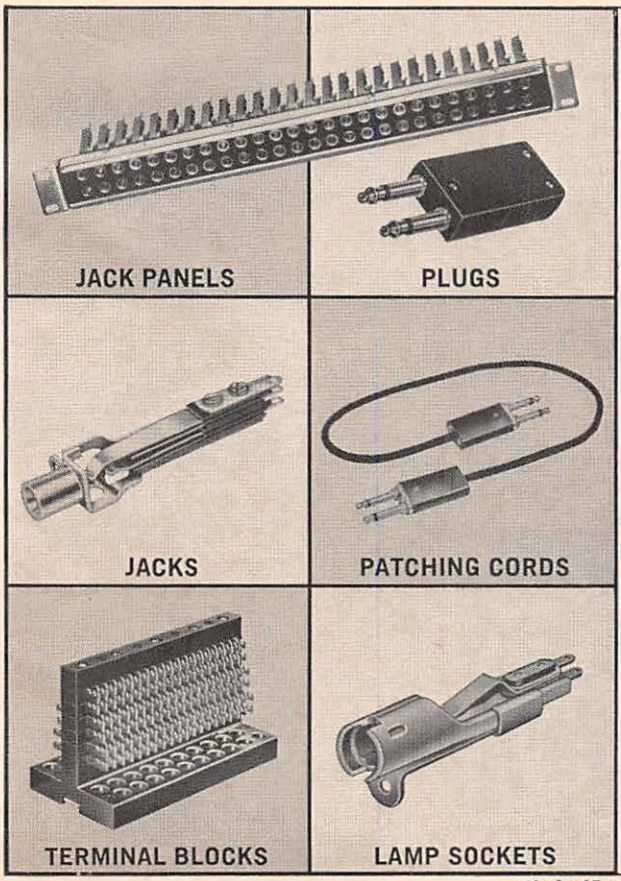
Mr. Clark was born in Terre Haute, Indiana on November 21, 1901. He began his railroad career as a car shop laborer in July 1918 and joined the Pennsylvania signal department one month later. He subsequently worked for the Big Four and the Atlantic Coast Line, returning to the PRR in 1923, advancing to signalman in 1926. Mr. Clark was elected vice general chairman in 1930 and became a full time officer January 1, 1935. He was elected assistant to B of RS president A. E. Lyon in August 1938. Since that time he served as acting vice president and secretary treasurer and assumed the duties as president May 1, 1945 to fill out an unexpired term. He was unanimously elected to the office in 1946 and at each subsequent convention.

Mr. Fields was born September 18, 1902. He entered signal service on the B & O in December 1920. He advanced through the ranks to inspector. Mr. Fields was elected general chairman on the B & O in 1945 and became vice president, eastern district, in 1952—the position he held until the time of his retirement.

The new president C. J. Chamberlain was born at Ashton, Ill. on August 7, 1921. He began his railroad career with the C&NW as an assistant signalman shortly after his graduation from public schools in 1938. He was promoted to signalman in 1943 and to leadman in 1944, becoming maintainer at Belvidere, Ill. in 1955. Mr. Chamberlain was appointed grand lodge representative in 1957 after having served with B of RS local and general committees. He was elected secretary treasurer in 1961 and unanimously re-elected to the post in 1964.

Mr. Drummond was born November 12, 1921. He received his education in the public schools. Mr. Drummond began his railroad career with the Washington Terminal in

(Please turn to page 38)



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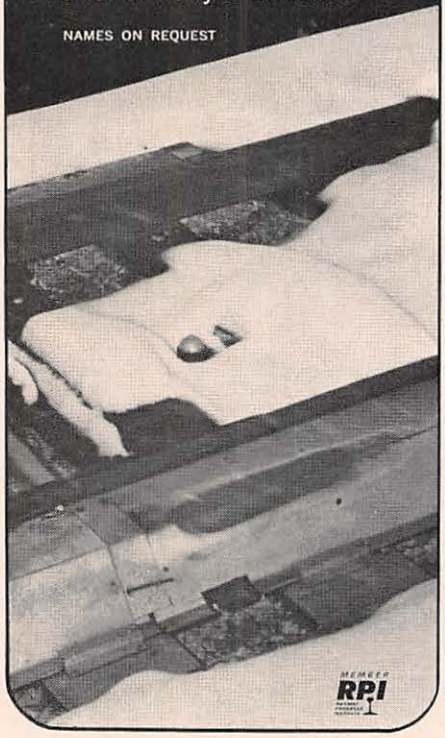

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VAPOR CORPORATION
6420 WEST HOWARD STREET, CHICAGO, ILLINOIS 60648
A Subsidiary of General Precision Equipment Corp.

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NEWS BRIEFS

(Continued from page 37)

1941. He advanced through the ranks to the position of leading maintainer. Mr. Drummond was appointed editor and manager of *The Signalman's Journal* in 1958 and became grand lodge representative in 1961. He was appointed B of RS vice president in November 1962 and elected to the post in 1964.

Mr. Frye was born in Thomasville, Pa. on December 16, 1923. He received his early education in the public schools and has continued his education by attending night courses in Chicago Junior College. Mr. Frye began his railroad career as a section laborer on the Pennsylvania in 1941 and was employed as a Southern Pacific signal helper in 1946 where he advanced to signalman. Mr. Frye was appointed grand lodge representative in 1958.

Mr. Bates is 40 years of age and was a line of road maintainer with the Southern Pacific before becoming general chairman in 1963. He was local chairman from 1958 to 1963.

• CANADIAN PACIFIC: **H. E. Worrell** is appointed signal supervisor to succeed **G. P. Stewart**, retired.

• ERIE LACKAWANNA: **Robert J. Cross**, communications supervisor, Mahoning Div, Youngstown, Ohio, retired July 31. **John J. Pappa** was appointed communications supervisor to succeed Mr. Cross.

• READING: **J. J. Foster** was named assistant chief signal, electrical and communications engineer. **R. A. Cicarone** is assistant electrical engineer. **R. C. Zieber** has been appointed assistant signal engineer—design. **J. E. Schweigert** was named assistant signal engineer—construction and maintenance and **A. F. Mill** was appointed communications engineer.

R. T. Bates
B of RS

Gordon Cavanagh
Copperweld

R. C. Ridley
Copperweld

Ralph Pyle
Copperweld

• SOUTHERN PACIFIC: **J. Foster, Jr.**, assistant superintendent of communications was appointed assistant general superintendent—communications. **H. W. Kornagay** succeeds Mr. Foster. **W. L. Fagley**, superintendent of communications, retired. **L. L. Rittenhouse** was appointed district communication supervisor, Sacramento, Calif. **J. D. Fraser** was named district communication supervisor, Houston, Texas. **W. B. Butler** was appointed microwave supervisor at Tucson, Arizona

(Please turn to page 40)

SBT 24–4.5 REGULATED POWER SUPPLY

Output voltage and current—
Output No. 1—24 volts ± 1 volt at 200 ma. continuous.
Output No. 2—4.5 volts ± .2 volts to 1500 ma. intermittent.
Output No. 3—20.7 volts ± .5 volt regulated to charge a 1 ampere hour lead-acid stand-by battery and maintain it at float charge level.

Ripple—
All three outputs less than 20 MV.

Physical Size—
5" x 7" x 3"

Circuitry—
Complete solid state type. Zener diodes and regular diodes provide voltage references.

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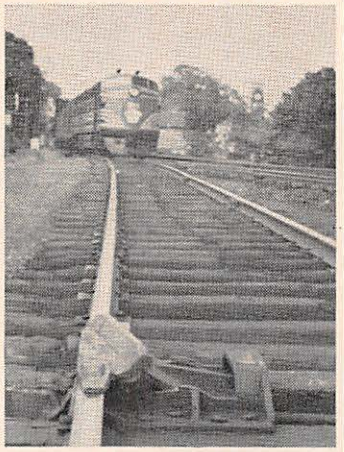
Hayes Derail—the most universally used track device. Designed and built by men whose only business is railroads.



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Specialists since 1903 in side track security

Hayes Track Appliance Co.

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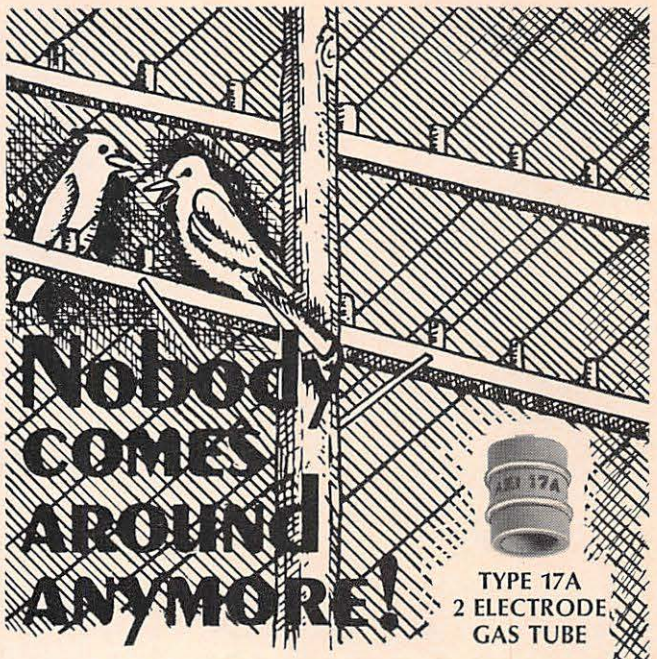

TYPE 17A
2 ELECTRODE
GAS TUBE

Since those new gas tube arresters were installed, we haven't seen a repairman in months.

Both AEI gas tube arrestors provide a high level of protection. Their ability to withstand repeated high voltage surges reduces maintenance costs.

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The type 17A gas filled protector is constructed of ceramic-metal and is designed to replace air gap protectors. It features a striking voltage of 200-500V d.c. fast operation, high security due to its heavy duty rating, and consequent longer life under adverse conditions. It will withstand 1,000 discharges from 1/250 surges of 150A/300A peak, tested up to 25 discharges per minute. It is available in 2 screw-in brass protector assemblies. (Codes 64A and 65A, shown at right) for direct replacement of carbon protectors. Manufactured under license from Western Electric.

CODE 65A
Screw Thread
7/16" x 20

CODE 64A
Screw Thread
1/2" x 20

TYPE 16 ARRESTER

Special construction of the Type 16 enables it to replace 2 conventional protectors. Since both gaps tend to break down simultaneously, it minimizes the excess voltage to which the apparatus is subjected. Current ratings — 20,000A (10/20 impulse) operating time is less than 1 microsecond.

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A wide range of mountings are available. Ask for a complete data file.

TYPE 16
3 ELECTRODE
GAS TUBE

AEI TELECOMMUNICATIONS EUGENE MUNSELL & CO.

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(Continued from page 38)

and **E. R. Chapman** to radio inspector, Los Angeles, Calif.

Supply Trade News

• COPPERWELD STEEL CO.: **Gordon Cavanagh,** executive assistant, was promoted to assistant vice president. **R. C. Ridley** was appointed administrative executive. **Ralph Pyle,** chief electrical engineer, was named product engineering chief in charge of the product engineering department. **Andrew Pudlak,** field engineer, was appointed manager of industrial sales.

• C. P. CLARE & CO.: **J. Douglas Littlejohn,** sales engineer at Los Angeles, is appointed western district sales manager at Chicago. He will be responsible for sales in 13 western states.

• EDISON PRIMARY BATTERY DIVISION: San Francisco and Chicago branch offices were consolidated and facilities at San Francisco were closed on August 15. **John M. Burton,** west coast representative has transferred to the Chicago office.

• FANSTEEL METALLURGICAL CORP: **Chris F. Seyer** was promoted to sales manager for the rectifier products division. He will direct domestic sales and advertising. Mr. Seyer, who earned a BSEE from Rice University in 1961, has been associated with the company since 1960.

• LYNCH COMMUNICATION SYSTEMS: **Leon F. Hamilton** and **Clifford E. Hopper** have been named area managers, communication engineering. Mr. Hamilton has been associated with Lynch since 1965. Mr. Hopper has been with Lynch since 1963.

L. F. Hamilton
Lynch

C. E. Hopper
Lynch

W. B. Rodemann
Varian Assoc.

F. T. Pascoe
S&C Div. WABCO

• MARQUARDT CORP: **Glen Ramsey** was appointed to Industrial Products in a consulting capacity. He was previously associated with Fansteel Metallurgical Corp.

• POOR & CO: **C. J. Miller** was appointed general manager–sales, railway products division; **P. J. Wolf** was appointed sales manager, **W. H. Russell,** assistant to general manager–sales, and **H. L. Lansing,** manager-engineering and manufacturing. **E. M. Gerulat** is service manager and **W. J. Acker, P. A. Cavett,** and **D. J. Corr** are district sales managers.

• UNION CARBIDE: **J. E. LeMay** has been appointed marketing manager–chemical products. **M. W. Westland** has been named to succeed Mr. LeMay as marketing manager–electrical and mechanical products.

Mr. Westland was graduated from Washington State College with a B.S. degree in electrical engineering in 1948. He joined the Carbon Products Division as a sales trainee in 1958.

• SIMMONS-BOARDMAN PUBLISHING CORP.: **John E. Rogers,** circulation manager for all publications, has been promoted to director of circulation.

• VARIAN ASSOCIATES: **Will B. Rodemann** has been appointed director, corporate marketing. He fills the position formerly held by **Robert T. Davis** who has returned to his position as professor of marketing at Stanford University. Mr. Rodemann is a graduate of Massachusetts Institute of Technology, where he received B.S. and M.S. degrees in electrical engineering and communications.

• WABCO–SIGNAL & COMMUNICATIONS DIV. has announced recent appointments. **F. T. Pascoe**–manager, mass transit and railroad systems, **C. R. Powdermaker**–manager, terminal systems, **G. F. McGlumphy**–manager, operations research, **C. E. Staples**–senior systems consultant, **J. A. Cook**–group manager of research and development. **D. R. Little** was named manager–servo control development and interim manager–mass transit systems. **H. L. Hathaway**–manager, railroad systems. **W. H. Moore**–manager, advanced technology, **E. O. Garrett**–manager, mechanical development, **E. R. Callender**–manager, digital development, **A. G. Pokrant**–manager, communications and electronic development, **R. W. Kennedy**–supervising engineer, program integration and technical services.

P. J. DeIvernois was appointed manager, terminal control, **D. D. Huffman**–manager, railroad control, **D. E. Stark**–manager, remote control, **J. L. Winning**–manager, mass

Andrew Pudlak
Copperweld

C. F. Seyer
Fansteel

Glen Ramsey
Marquardt

M. W. Westland
Union Carbide

C. R. Powdermaker
S&C Div. WABCO

G. F. McGlumphy
S&C Div. WABCO

C. E. Staples
S&C Div. WABCO

James A. Cook
S&C Div. WABCO

G. W. Baughman
S&C Div. WABCO

M. C. Blevins
Kerite

transit control, **O. T. Schumm**—supervisor engineering services.

Harold H. Gudenrath was appointed sales engineer, eastern regional office, Philadelphia, Pa. He was associated with the signal and communication department of the Reading for 20 years prior to his assignment. Mr. Gudenrath studied electrical engineering at Drexel Institute of Technology.

George W. Baughman, recently retired from WABCO has accepted a position as a consultant with the Department of Transportation. Mr. Baughman was born in Gilboa, Ohio on Feb. 11, 1900, and graduated from Ohio State university in 1920 with a degree in electrical engineering. He joined Union Switch & Signal in 1923 and was active in many developments in signaling and communications. He became chief engineer in 1945, and in 1950 was made assistant vice-president, engineering. In 1961, he became assistant to the president, WABCO. He retired recently.

Obituaries

• GEORGE D. BOOTH, retired office engineer—signals & communications, Norfolk & Western at Cleveland, died recently.

• MARSHALL C. BLEVINS, assistant to the president, Kerite Co., at Chicago, died recently.

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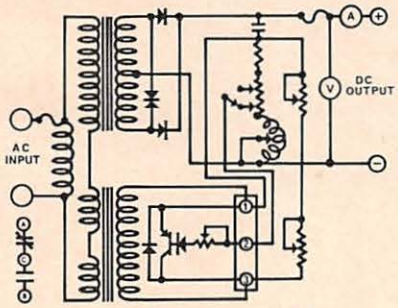
Railroad Battery Rectifiers

For Signal, Communications and Engine Starting Applications . . . La Marche Railroad Battery Rectifiers



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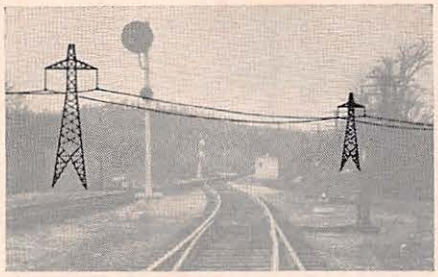

HVDC ground will corrode lead cable

It is proposed by the Bonneville Power Administration (BPA) to transmit HVDC power via a balanced line. Balanced transmission lines pose little or no corrosion problems to buried lead telephone cables; however, because of the use of ground return under fault conditions or scheduled line repairs the corrosion aspects of continuous ground return operation have been considered.

A theoretical analysis of the corrosion problem has been made to establish the relationship between the apparent earth resistivity, the leakage current on buried cables and the current at the electrode. Formulae are presented which permit determination of the minimum separation required between buried noninsulated cables and a current electrode. Field measurements made at The Dalles, Oregon and applied to the equations indicate that with a current electrode operating at 2,000 amps, a minimum separation of 3.5 miles is required between it and adjacent noninsulated cables.

The leakage current at a break in the coating of insulated cables is also considered, but the unknown quantity of leakage resistance of the jacket, prevents the development of useful general approximations.

The Bonneville Power Administration invited the Bell System to participate in preliminary tests involving High Voltage Direct Current (HVDC) transmission. The particular questions involving the Bell System were (1) would such transmission result in noise problems in adjacent telephone lines, and (2) was there any corrosion hazard to buried lead communications cable in the vicinity of a current electrode associated with the HVDC system.

The principle advantages of DC transmission accrue from the use of smaller and hence less costly towers, two lines for a balanced system instead of the three for AC, possible use of high voltage underground transmission cables because of no inductive loss and elimination of phasing problems at the terminal points with local distribution networks. Ground return operation is another economic advantage, which would reduce the system to a lower resistance single line, but this is not proposed for the present installation. However, the possibility of one pole of the transmission system being taken out of service by a fault or to schedule repairs, requires ground return operation through an electrode ground bed installed at each end.

One of the reasons for Bell Telephone Laboratories' participation in the tests conducted by the BPA was to determine what separation should be maintained between a buried lead cable and a DC ground electrode.

Considering the earth as a conductor for direct current, uniform earth resistivity is seldom found when going to great depths, and the apparent resistivity may be far different from values which are obtained by surface resistivity measurement.

If a buried lead sheath cable lies within the area influenced by a current electrode, a portion of the current will flow on the cable because the potential of the earth will vary along the length of the cable.

Thus far the consideration has been for bare cables in direct contact with the ground. For polyethylene jacketed lead cables, or insulated coatings such as are found on buried pipe lines, a small hole in the sheath will result in leakage current densities up to 100 times higher than for bare lead cables at the same separation since the current is concentrated at these holes.

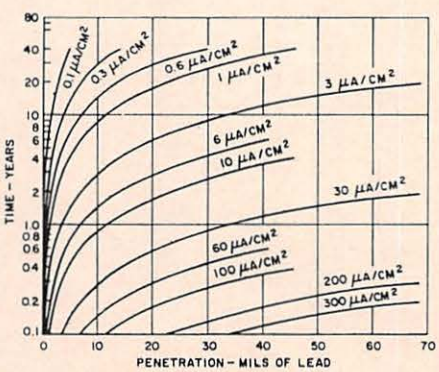

Figure 1: Penetration vs time.

In order to determine the corrosion hazard to buried plant, a value for tolerable current leakage must be chosen. Figure 1 shows a family of curves which correlate penetration of lead with time for given values of current leakage. If one establishes the value for loss of wall thickness that can be tolerated and the anticipated time of exposure, then the current density can be read directly from the graph. The maximum allowable corrosion of the sheath was conservatively chosen to be 10% uniformly distributed over the surface. The service life of such a cable should be 40 years.

The corrosion of cables at pinholes in insulated jackets, such as extruded polyethylene, depends on the size of the hole.

It is concluded that if a ground return DC transmission system were to operate in the vicinity of The Dallas, Oregon at 1800 amperes (continuous ground return), a minimum separation of 3.5 miles would be required between a buried noninsulated lead telephone cable and the current electrode. **RS&C**

Note: Abstract of Paper by L. E. Fiorito at a Symposium on Effects of HVDC Transmission on Railway Operations, held in Denver, Colo. Mr. Fiorito is associated with the Bell Telephone Laboratories, Inc. The paper was presented by George Schick, also associated with Bell Laboratories. The full paper titled *"Corrosion Aspects of HVDC on Buried Telephone Plant"* is included in the papers and proceedings of the Symposium now available at $5.00 per set. Write George McCann, Secretary, Communication & Signal Section, AAR, 59 East Van Buren St., Chicago, Ill. 60605.

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TYPE Y

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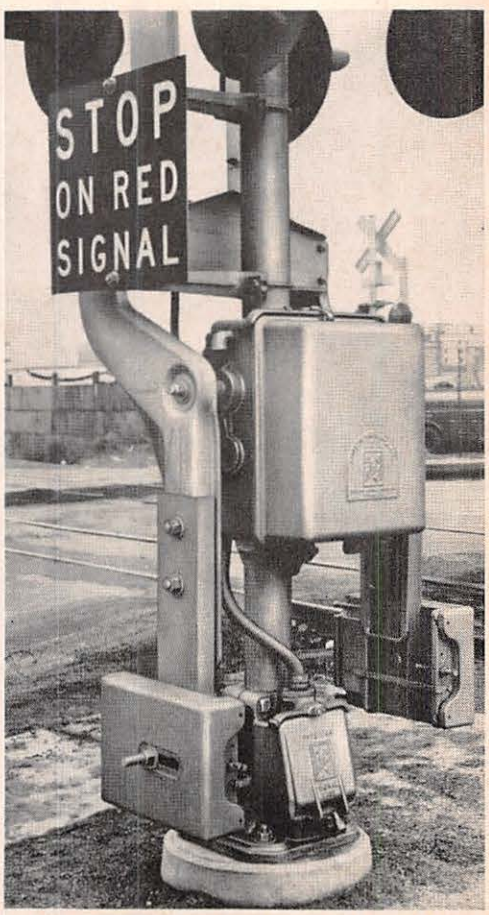

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